PREUSSAG
Meerestechnik/Marine Technology

SO 39

GARIMAS 2

GALAPAGOS RIFT MASSIVE SULPHIDES

CRUISE REPORT

15.07.1986

PREUSSAG MEERESTECHNIK

GARIMAS 2

GALAPAGOS RIFT MASSIVE SULPHIDES

CRUISE 39 OF MS SONNE

04.07. - 18.10.1985

CRUISE REPORT

AUTHORS:

J. POST, PREUSSAG
J. LANGE, PREUSSAG
H. BÄCKER, PREUSSAG
K. BARNSTORF, PREUSSAG
H. SULZBACHER, PREUSSAG
G. WEBER, PREUSSAG
K. BECKER, RWTH AACHEN
P.H. TSE, UNIV. HAMBURG

0-2015-0031
GEOMAR Bibliothek Ostufer Kiel

HANNOVER, 15.07.1986

CONTENTS

ZUSAMMENFASSUNG

GARIMAS 2 (Galapagos Rift, Massivsulfide) war die zweite Phase eines Explorationsprogrammmes, welches in dem Teil des Galapagos Rifts durchgeführt wurde, der zur Wirtschaftszone von Ecuador gehört. GARIMAS 2 wurde als 39. Fahrt des deutschen Forschungsschiffes SONNE durchgeführt.
Die Fahrt begann am 4. Juli 1985 in Hawaii und endete am 18. Oktober 1985 in Callao (Peru). Die Beladung fand am 20. und 21. Juli in Balboa (Panama) statt und die Entladung am 18. und 19. Oktober in Callao.
Hauptaufgabe der GARIMAS 2 war die Gewinnung einer genügend großen Menge an Massivsulfiden. Gestützt auf die Ergebnisse der früheren GEOMETEP-Fahrten und der GARIMAS 1-Fahrt wurde das gesamte Riftsystem zwischen 85° und 95°W bathymetrisch kartiert. Für diesen Zweck wurden 447 bathymetrische Profile mit einer Gesamtlänge von 9726 km (5252 sm) durchgeführt.
In besonderen Abschnitten des Rifts wurden Detailuntersuchungen mit Hilfe des Foto-TV-Schlittens OFOS (Ocean Floor Observation System) durchgeführt. Auf 62 OFOS-Profilen wurden mehr als 30.000 Aufnahmen gemacht.
Zusätzliche Bodenbeobachtungen konnten auf 106 TV-Greifer-Stationen gesammelt werden. Die Ausbeute dieser Greifer-Stationen belief sich auf mehr als 20 Tonnen Massivsulfide, die auf 4 verschiedenen Lokationen gesammelt wurden.

SUMMARY

GARIMAS 2 (Galapagos Rift Massive Sulphides) was the second phase of an exploration programme within that part of the Galapagos Rift which belongs to the exclusive economic zone (EEZ) of Ecuador. It was carried out as the 39th cruise of the German research vessel SONNE.
The cruise started on July 4, 1985 in Hawaii and ended on October 18, 1985 in Callao (Peru). Mobilization took place in Balboa (Panama) on July 20 and 21 and demobilization was carried out on October 18 and 19 in Callao.
The main purpose of GARIMAS 2 was the sampling of a sufficient amount of massive sulphides. Based on previous work performed during the different GEOMETEP cruises and the GARIMAS 1 cruise the entire rift system between 85° and 95°W was charted bathymetrically. For this purpose a number of 447 bathymetric profiles with a total length of 9726 km (5252 nm) were carried out.
Detail investigations were carried out on special sections of the rift applying the visual monitoring system OFOS (Ocean Floor Observation System). During 62 OFOS-tracks more than 30,000 seafloor photos were taken.
Additionally, visual bottom observations were carried out on 106 TV-grab stations. The yield of these grab stations amounted to more than 20 tons of massive sulphides sampled at four different locations.

1. INTRODUCTION

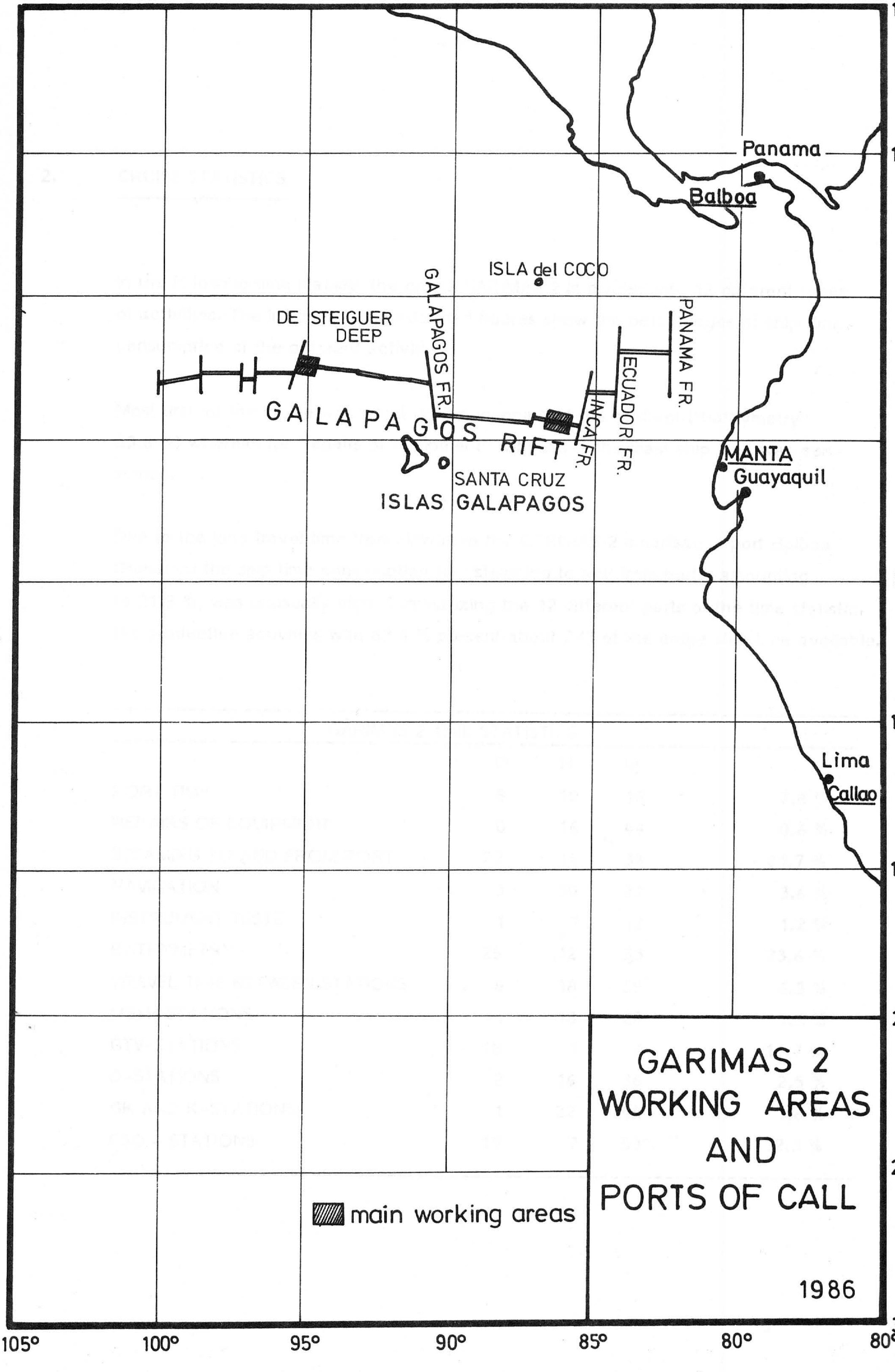
Cruise 39 of MS SONNE is named GARIMAS 2 (Galapagos Rift Massive Sulphides). It is the continuation of a research effort aimed at the understanding of ore-forming processes along the Galapagos spreading centre between 85 and 95°W.

Based upon the previous work done within the scope of the projects GEOMETEP and GARIMAS 1 as well as various American cruises the Cocos/Nazca plate boundary was mapped and sampled much in detail. Emphasis was laid upon the recovery of major amounts of sulphides of iron, copper and zinc, using the most modern techniques of TV-guided grabs.

The work was authorized by the Ecuadorian Ministerio de Recursos Naturales y Energeticos and by the Direccion General de Intereses Maritimos, Armada del Ecuador.

This report describes the performance of cruise SO 39, the methods and equipment used, the survey areas and first results.

GARIMAS 2 was sponsored by the Bundesministerium für Forschung und Technologie, Bonn. PREUSSAG AG thanks for the support of this project.


GARIMAS 2
WORKING AREAS
AND
PORTS OF CALL
1986
main working areas
Panama
Balboa
ISLA del COCO
DE STEIGUER
DEEP
GALAPAGOS FR.
PANAMA FR.
ECUADOR FR.
INCA FR.
GALAPAGOS RIFT
SANTA CRUZ
ISLAS GALAPAGOS
MANTA
Guayaquil
Lima
Callao
15°
10°
5°
0°
5°
10°
15°
20°
25°
30°
105°
100°
95°
90°
85°
80°
80°

2. CRUISE STATISTICS

In the following time statistic the cruise GARIMAS 2 is divided into 12 different types of activities. The listing and the attached figures show the percentages of ship time consumption of the different activities.

Most time of the cruise was spent on the mapping of the seafloor ("bathymetry" 23.6 %) whereas for "repairs of equipment" with 0.6 % the least ship time was consumed.

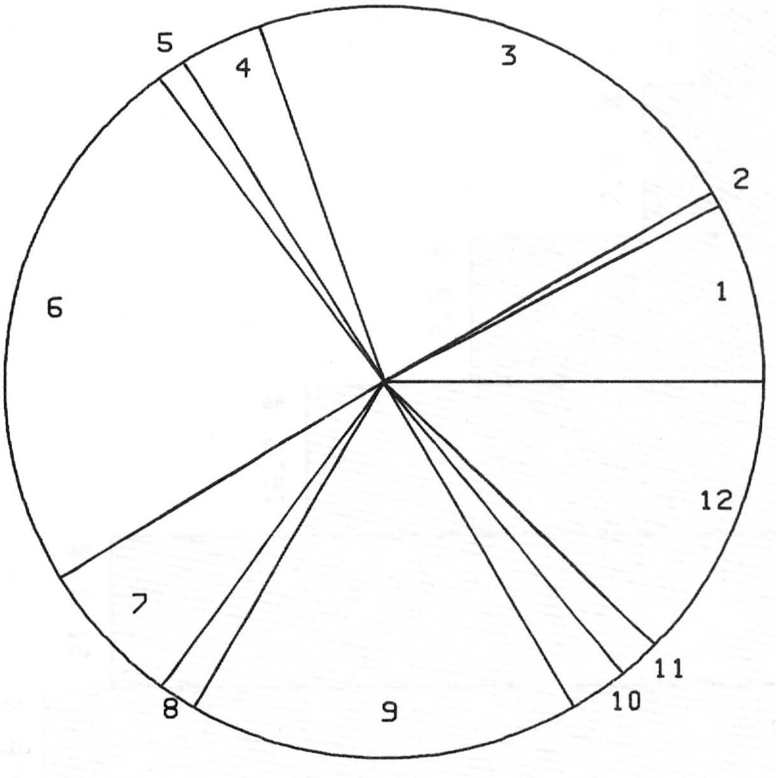
Due to the long travel time from Hawaii to the GARIMAS 2 mobilisation port Balboa (Panama) the ship time consumption for "steaming to and from port", amounting to 21.9 %, was unusually high. Summarizing the 12 different parts of the time statistic the productive activities with 63.4 % present about 2/3 of the entire ship time available.

GARIMAS 2 TIME STATISTICS

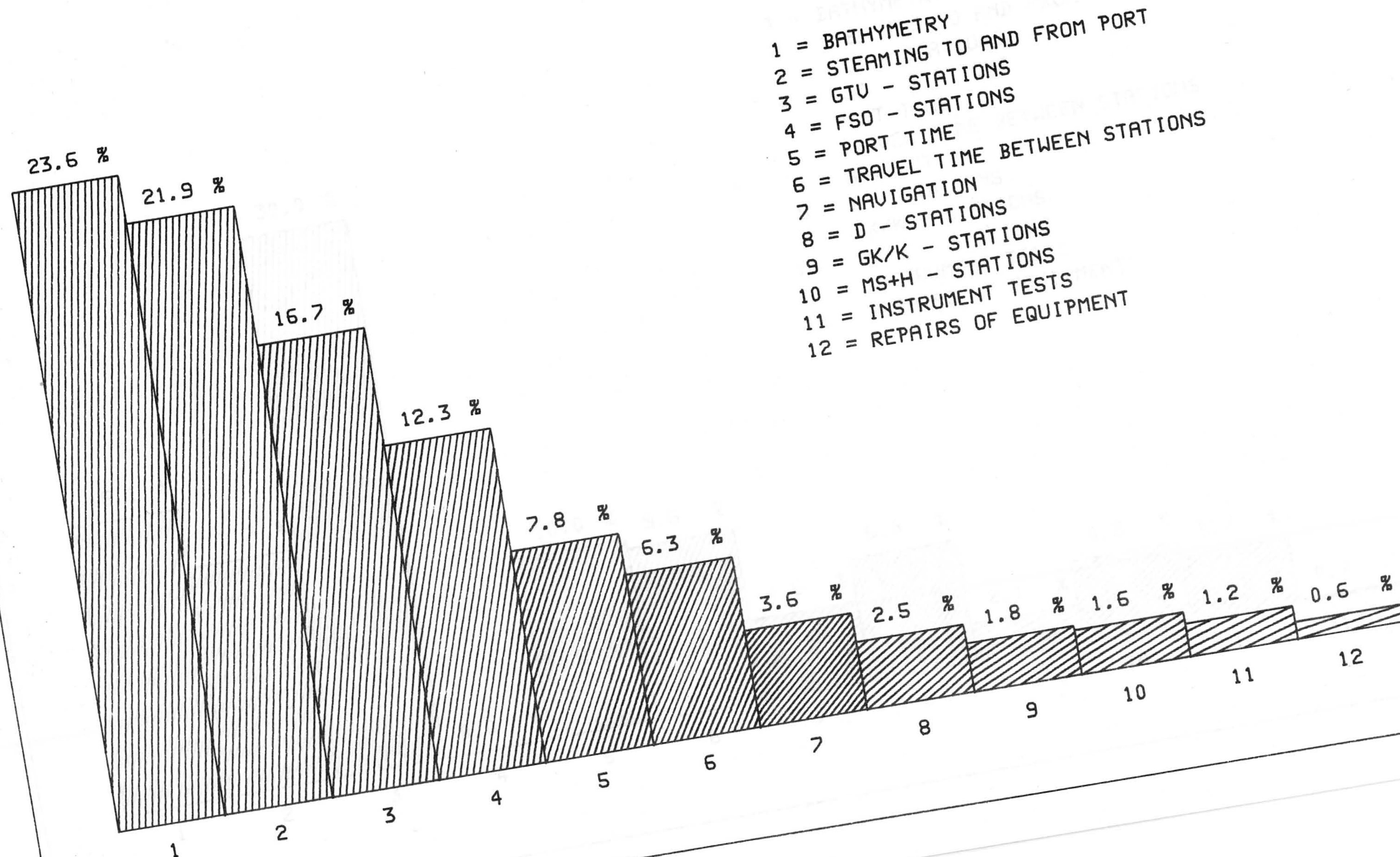
	D	H	M	
PORT TIME	8	10	18	7.8 %
REPAIRS OF EQUIPMENT	0	16	44	0.6 %
STEAMING TO AND FROM PORT	23	14	34	21.7 %
NAVIGATION	3	30	21	3.6 %
INSTRUMENT TESTS	1	7	32	1.2 %
BATHYMETRY	25	12	53	23.6 %
TRAVEL TIME BETWEEN STATIONS	6	18	59	6.3 %
MS+H STATIONS	1	18	20	1.6 %
GTV-STATIONS	18	1	6	16.7 %
D-STATIONS	2	16	36	2.5 %
GK AND K-STATIONS	1	22	44	1.8 %
FSO - STATIONS	13	7	53	12.3 %

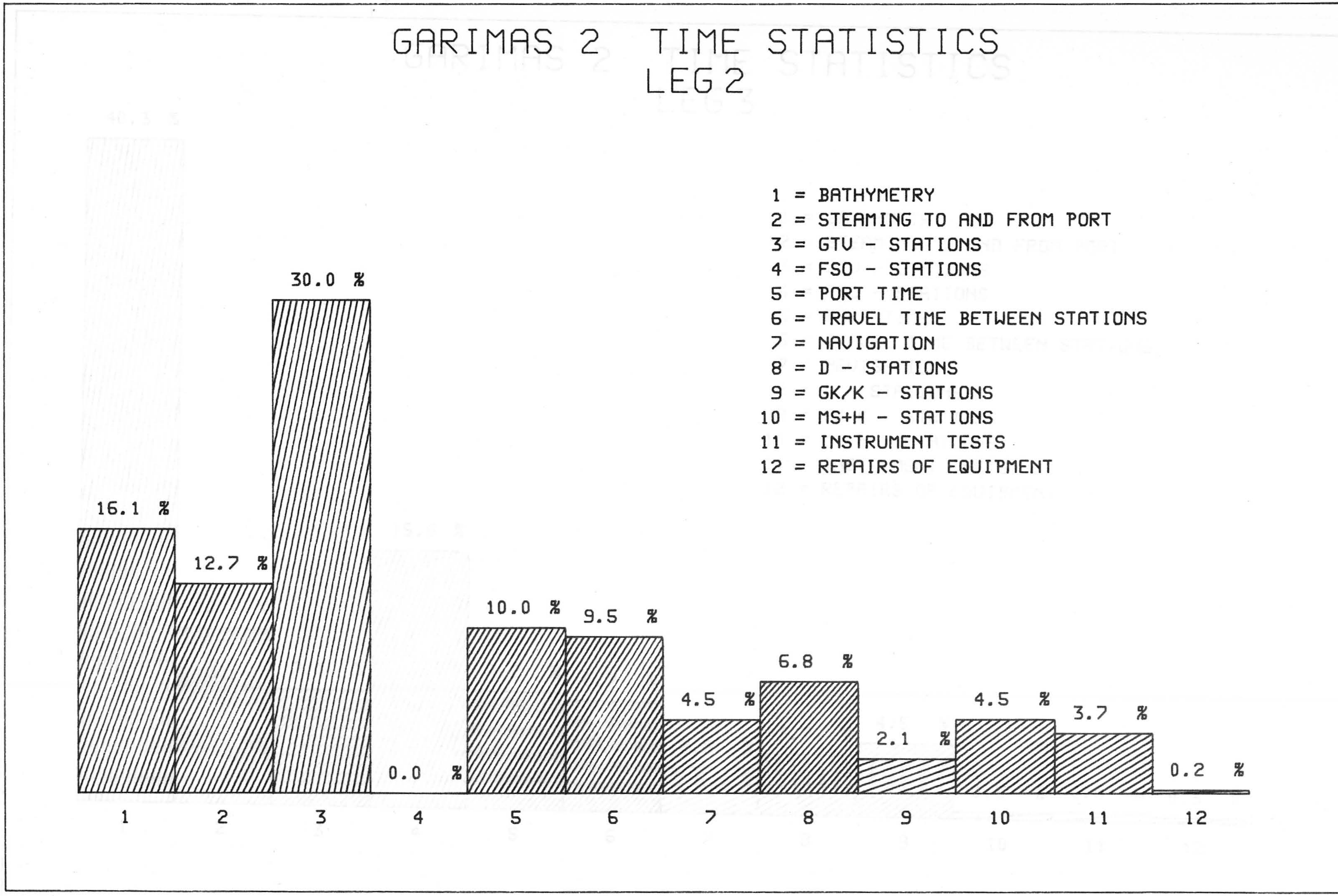
GARIMAS 2 TIME STATISTICS

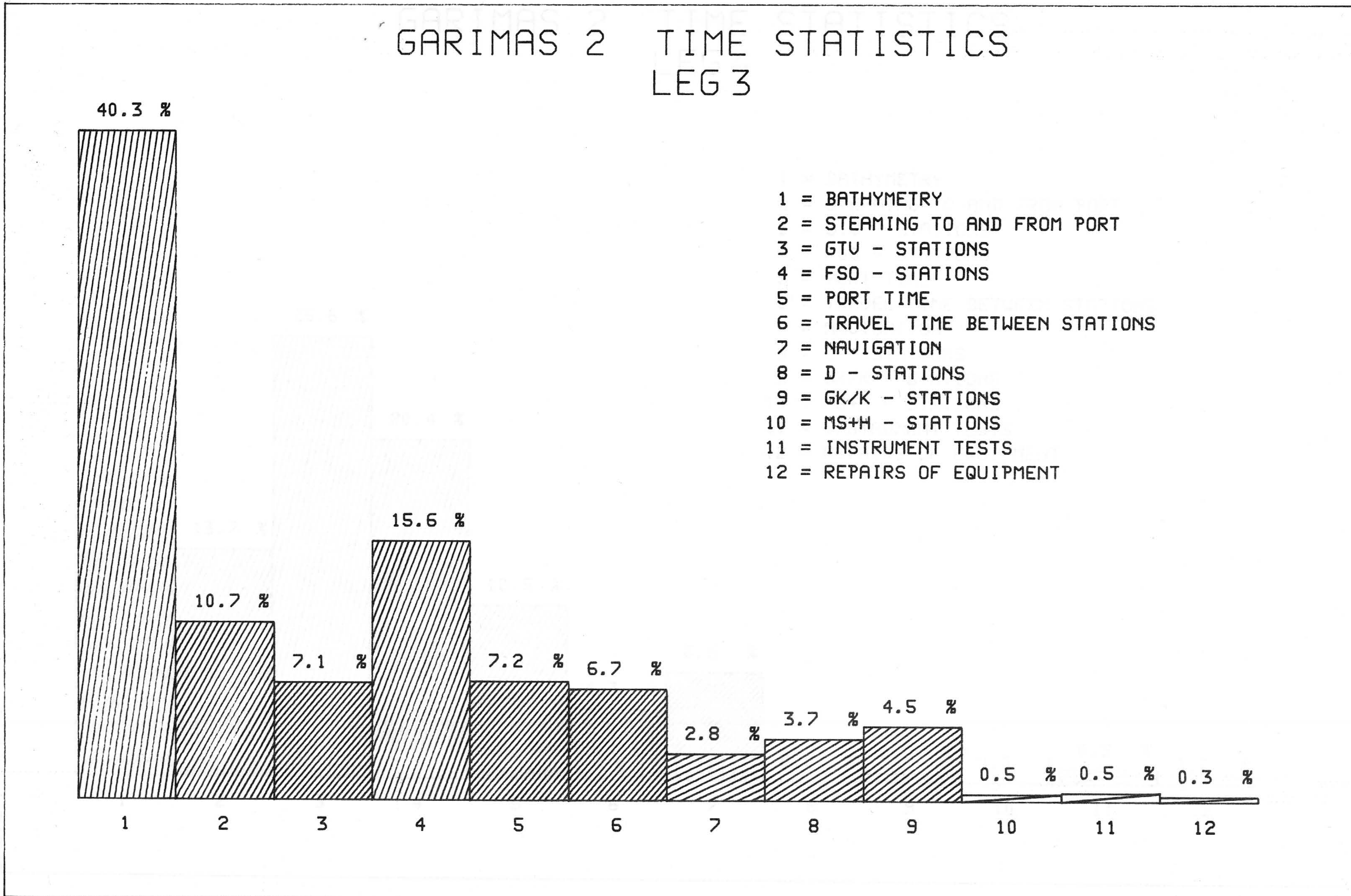
1 =	PORT TIME	7.8 %
2 =	REPAIRS OF EQUIPMENT	0.6 %
3 =	STEAMING TO AND FROM PORT	21.9 %
4 =	NAVIGATION	3.6 %
5 =	INSTRUMENT TESTS	1.2 %
6 =	BATHYMETRY	23.6 %
7 =	TRAVEL TIME BETWEEN STATIONS	6.3 %
8 =	MS+H - STATIONS	1.6 %
9 =	GTV - STATIONS	16.7 %
10 =	D - STATIONS	2.5 %
11 =	GK and K - STATIONS	1.8 %
12 =	FSO - STATIONS	12.3 %

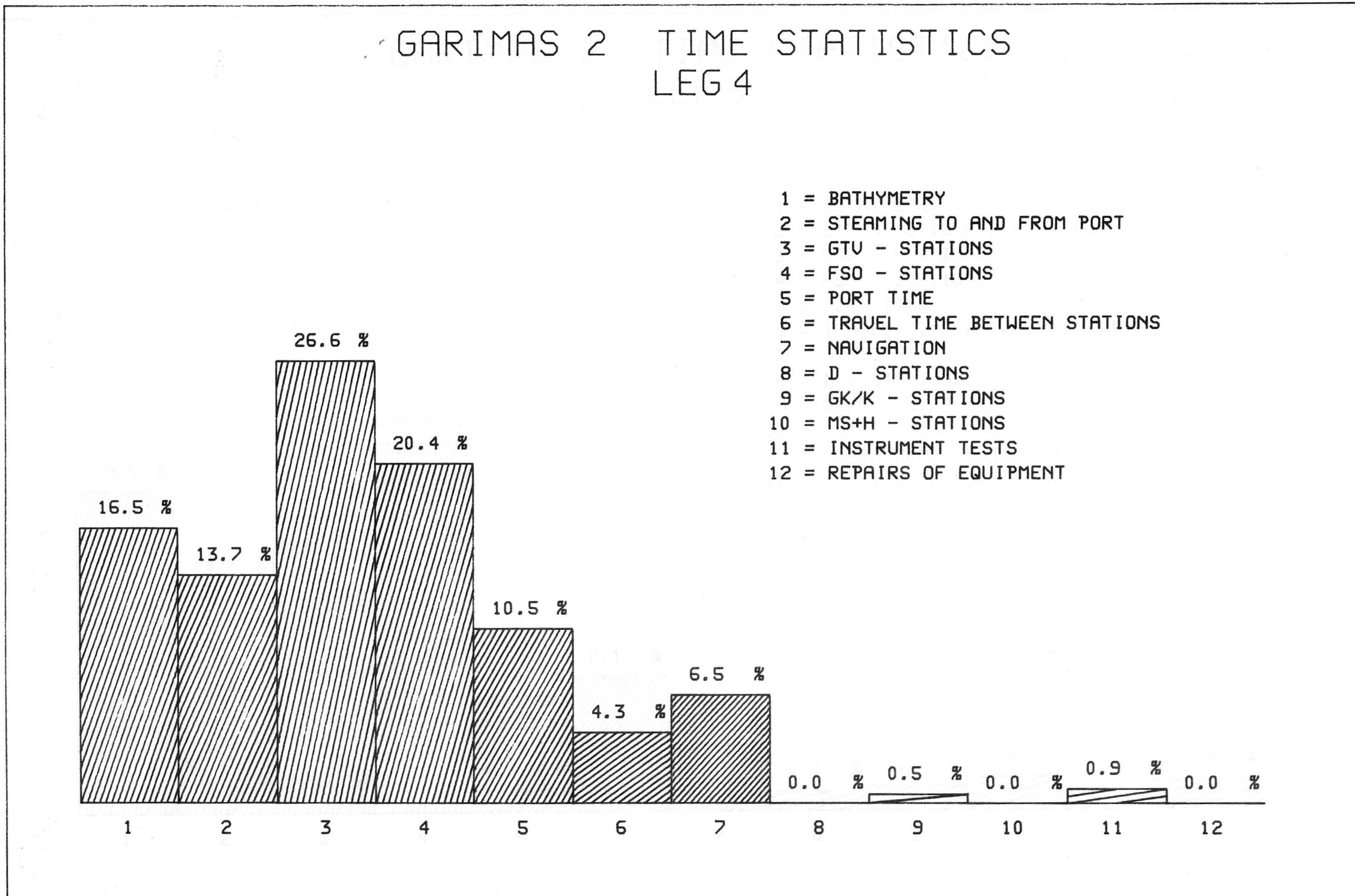


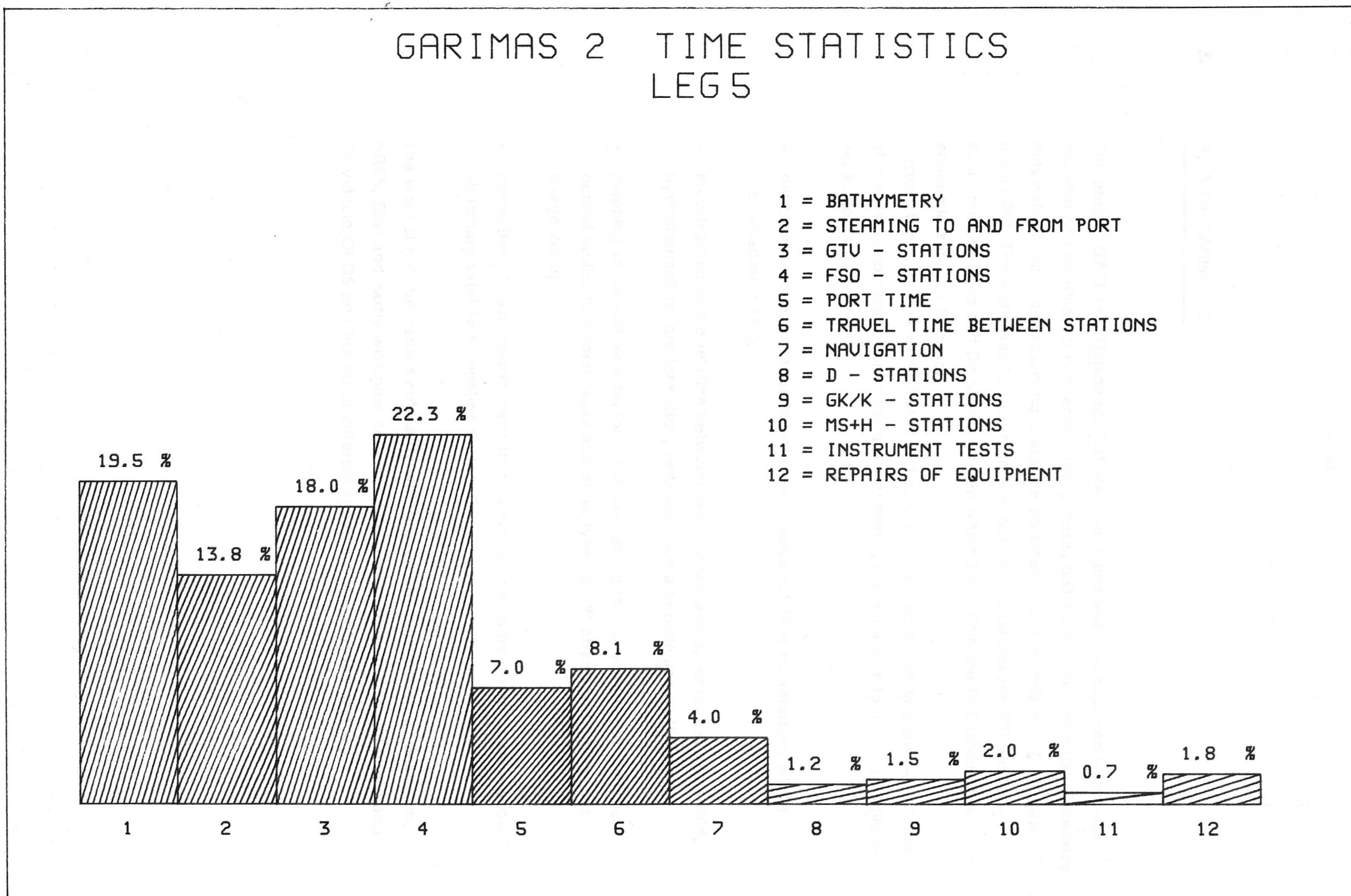
GARIMAS 2 TIME STATISTICS




GARIMAS 2 TIME STATISTICS
LEG2
1 = BATHYMETRY
2 = STEAMING TO AND FROM PORT
3 = GTV - STATIONS
4 = FSO - STATIONS
5 = PORT TIME
6 = TRAVEL TIME BETWEEN STATIONS
7 = NAVIGATION
8 = D - STATIONS
9 = GK/K - STATIONS
10 = MS+H - STATIONS
11 = INSTRUMENT TESTS
12 = REPAIRS OF EQUIPMENT
16.1 %
12.7 %
30.0 %
0.0 %
10.0 %
9.5 %
4.5 %
6.8 %
2.1 %
4.5 %
3.7 %
0.2 %
1
2
3
4
5
6
7
8
9
10
11
12


GARIMAS 2 TIME STATISTICS
LEG 3
40.3 %
10.7 %
7.1 %
15.6 %
7.2 %
6.7 %
2.8 %
3.7 %
4.5 %
0.5 %
0.5 %
0.3 %
1 = BATHYMETRY
2 = STEAMING TO AND FROM PORT
3 = GTV - STATIONS
4 = FSO - STATIONS
5 = PORT TIME
6 = TRAVEL TIME BETWEEN STATIONS
7 = NAVIGATION
8 = D - STATIONS
9 = GK/K - STATIONS
10 = MS+H - STATIONS
11 = INSTRUMENT TESTS
12 = REPAIRS OF EQUIPMENT
1
2
3
4
5
6
7
8
9
10
11
12


GARIMAS 2 TIME STATISTICS
LEG 4
1 = BATHYMETRY
2 = STEAMING TO AND FROM PORT
3 = GTV - STATIONS
4 = FSO - STATIONS
5 = PORT TIME
6 = TRAVEL TIME BETWEEN STATIONS
7 = NAVIGATION
8 = D - STATIONS
9 = GK/K - STATIONS
10 = MS+H - STATIONS
11 = INSTRUMENT TESTS
12 = REPAIRS OF EQUIPMENT
16.5 %
13.7 %
26.6 %
20.4 %
10.5 %
4.3 %
6.5 %
0.0 %
0.5 %
0.0 %
0.9 %
0.0 %
1
2
3
4
5
6
7
8
9
10
11
12


GARIMAS 2 TIME STATISTICS
LEG5
1 = BATHYMETRY
2 = STEAMING TO AND FROM PORT
3 = GTV - STATIONS
4 = FSO - STATIONS
5 = PORT TIME
6 = TRAVEL TIME BETWEEN STATIONS
7 = NAVIGATION
8 = D - STATIONS
9 = GK/K - STATIONS
10 = MS+H - STATIONS
11 = INSTRUMENT TESTS
12 = REPAIRS OF EQUIPMENT
19.5 %
13.8 %
18.0 %
22.3 %
7.0 %
8.1 %
4.0 %
1.2 %
1.5 %
2.0 %
0.7 %
1.8 %
1
2
3
4
5
6
7
8
9
10
11
12

3. AIMS OF GARIMAS 2

The project GARIMAS (Galapagos Rift Massive Sulphides) was designed to provide material and information concerning the genesis, distribution and potential of massive polymetallic sulphides occurring along the divergent plate boundaries of the Galapagos Rift. The work was focussed on that part of the Galapagos Rift between Inca Fracture Zone and De Steiguer Deep which lies within the EEZ (exclusive economic zone) of Ecuador.
Besides the main task of GARIMAS 2, i.e. to collect a sufficient amount (≥ 10 tons) of massive sulphides for processing experiments, the work was focussed on following subjects:

- detection and reconnaissance of new massive sulphide occurrences within the Ecuadorian EEZ;
- investigation of the relation between seafloor spreading, tectonics, volcanism, hydrothermalism, ore formation, sedimentation and biological activity;
- mapping of the different tectonic features along the Galapagos Rift such as normal faults, transform faults and other types of rift offsets, rift valley and o-age zone;
- correction of bathymetric maps from previous cruises by using the new geostationary satellite navigation system GPS.

The work should be carried out partly with proven equipment such as Seabeam, NBES, SBP and partly with new developed devices such as the towed photo and TV vehicle OFOS and the three different types of TV-controlled grabs.

4. PARTICIPANTS

Besides the nautical crew of R/V SONNE which included, taken all together, 32 persons (Tab. 4.1), a number of 31 scientists, engineers and technicians participated in GARIMAS 2 (Tab. 4.2). Most of the scientific and technical staff members belonged to Preussag. The permanent scientific-technical staff on board comprised 18 to 20 persons. 16 persons were exchanged during port calls. During the third and fourth leg there were Ecuadorian representatives from the Instituto Oceanografico de la Armada (INOCAR) and from the Instituto Ecuadoriano de Mineria (INEMIN) on board.

Additionally, one scientist of the University of Hamburg and two scientists of the University of Aachen participated in the GARIMAS 2 cruise.

Three engineers of the University of Hannover attended the GPS navigation system.

TAB. 4.1:

PERSONNEL NAUTICAL CREW

FUNCTION	21.07.-02.09.85	03.09.-17.09.85	18.09.-18.10.85
Master	Müller, G.		
Ch. Mate	v. Minden, H.		
2nd Mate	Hempel, C.		
R.O.	Bruhns, H.		Schumann
Ch. Eng.	Ziemann, I.		
2nd Eng.	Rex, A.		
2nd Eng.	Heidorn, R.		
Storekp.	Ruelke, U.		
Electr.	Arndt, D.		
Electr.	Schmidt, H.		
Mot. man	Irion, A.		
Mot. man	Schymatzek, P.		
Mot. man	Zarott, W.		
Mot. man	Schomaker, R.		
1st Cook	Helwig, J.		
2nd Cook	Gruen, F.		
1st Stew.	Schwinger, A.		
2nd Stew.	Viett, B.	Tiedemann, G.	
2nd Stew.	Schaap, P.		Richter, T.
Boats w.	Adelmann, H.		Gründinger, E.
A.B.	Brummerhop, H.-J.		
A.B.	Pitzoff, R.	Meyer T.	
A.B.	Zilinski, G.		
A.B.	Jahns, W.		Schäper, A.
A.B.	Meyer, D.		
A.B.	Sünder, H.-J.		

TAB. 4.2:

PERSONNEL SCIENTIFIC-TECHNICAL CREW

NAME	FUNCTION	INSTITUTION	1ST LEG 04.07.-20.07.	2ND LEG 21.07.-13.08.	3RD LEG 14.08.-02.09.	4TH LEG 03.09.-17.09.	5TH LEG 18.09.-18.10.
Bäcker, H.	Operation management	PREUSSAG		x	x	x	x
Lange, J.	Geology	PREUSSAG		x	x	x	x
Probst, U.	Geology	PREUSSAG CONTR.		x	x	x	x
Post, J.	Oceanography	PREUSSAG		x	x	–	–
Sulzbacher, H.	Geophysics	PREUSSAG		x	x	–	–
Monenschein, J.	Geophysics	PREUSSAG		–	–	x	x
Weber, H.	Metallurgy	PREUSSAG		x	–	–	–
Weber, G.	Photo-Geology	PREUSSAG		–	–	–	x
Meyer, W.	Electronics	PREUSSAG	x	x	x	x	–
Thiele, H.	Mechanics	PREUSSAG		x	x	x	x
Spoetter, M.	Mechanics	PREUSSAG		x	x	x	x
Bayer, F.	Geophysics	PREUSSAG	x	x	x	x	x
Pohl, W.	Geophysics	PREUSSAG		–	–	–	x
Voehrs, H.	Electronics	PREUSSAG		x	x	x	x
Keipke, D.	Electronics	PREUSSAG		–	x	x	x
Hoffmann, H.	Electronics	PREUSSAG		x	x	x	x
Stammer, K.	Electronics	PREUSSAG		x	x	–	–
Barnstorf, K.	Geology	PREUSSAG		x	x	x	x
Simon, D.	Ship's Doctor	PREUSSAG CONTR.		x	x	x	x
Klaszen, O.	Mechanics	PREUSSAG		x	x	x	x
Wilke, M.	Geology	PREUSSAG CONTR.		–	–	x	x
Tse, P.H.	Chemistry	UNI HAMBURG		x	–	–	–
Speich, S.	Oceanography	PREUSSAG CONTR.		–	–	x	x
Schuchardt, A.	Navigation	UNI HANNOVER		x	–	–	–
Heimberg, F.	Navigation	UNI HANNOVER		x	x	x	–
Brüggemann, A.	Navigation	UNI HANNOVER		–	–	–	x
Moncayo, C.	Guest Ecuador	INOCAR		–	x	–	–
Herrera, G.	Guest Ecuador	INEMIN		–	x	–	–
Herzig, P.	Geology	UNI AACHEN		–	x	–	–
Becker, K.-P.	Geology	UNI AACHEN		–	x	x	–
Viteri, F.	Guest Ecuador	INEMIN		–	–	x	–
Rada, F.	Guest Ecuador	INOCAR		–	–	x	–

5. NARRATIVE

Originally SONNE cruise 39 was designed to start in Honolulu to allow for some sampling at the known sulphide sites at the EPR near 13°N. However, delays caused by finanzing problems resulted in the choice of Panama as the embarkation harbour for most of the scientific party. During cruise leg 1 (Honolulu - Panama) only 2 people of the scientific staff were on board to prepare the equipment. The SO-39 programme was essentially based on new equipment, the ocean floor observation system (OFOS) and three TV-guided grabs, one of which was already tested during GARIMAS 1, the other two were new. Further new achievements were the global positioning system (GPS) operated by two scientists of Hannover University, and the RS 904-ultra-short base positioning system for towed vehicles. Furthermore, during one month close cooperation was practized with the American research vessel ATLANTIS II, which carried the deep diving vehicle ALVIN.

SONNE arrived in Balboa on July 21. The scientific-technical crew boarded on July 21 and 22. Three containers, carrying the equipment and consumption material, were loaded. The supply with contaminated battery acid from local sources caused some problems during the whole cruise.

On July 23, SONNE headed for the Galapagos Rift. The next day, GPS was operative, and became a very useful navigation aid for the future. Unfortunately, the limited number of available satellites limited the reception time to about 10 - 11 hours/day. During the transit time, work focused on the preparation of the equipment. Already on July 25, the latest TV-grab development, the polyp grab GTVC was lowered for the first time into the water. The sampling test was fully successful, and about 2 tons of foraminiferal nanno ooze were lifted on deck.

On July 26, early in the morning, SONNE was on location near the Galapagos Rift axis at 85°55'W. After carrying out one multisonde station, to calibrate the Seabeam charting system, an Atnav-transponder navigation array was established to provide sufficient positioning accuracy outside the GPS-time within the Area B, where new sulphide sites had been located during GARIMAS 1. Four transponder moorings were launched, one carrying a current meter. On September 5 the array was amplified by 2 additional transponders. During the next days, the work began on 4 lines: a) bathymetry, to fill gaps in the old Seabeam maps, b) rock sampling, using the TV-grab GTVC, c) multisonde measurements, to detect active hydrothermal sites,

and d) spade corer stations to assess the metal dispersion from the axial area during the past. The two last operations were part of a doctoral thesis of P.H. Tse of Hamburg University. The first sulphides were recovered at station 11 GTVC on July 28. TV-grab GTVB was tested for the first time the next day, but the telemetry box was flooded at 1,480 m water depth, which provided sufficient work for the electronicians for the next days. Station 16 GTVC next day was disappointing as well: The sample taken in a sulphide field located last year by photos proved to be entirely oxidized, and most material was washed out during hoisting of the grab. The remaining material showed only 0.13 % Cu and 0.24 % Zn, but still 19.2 % Fe. This phenomenon was observed later on at various inactive hydrothermal sites. On other occasions (e.g. 17 GTVC), sulphides could be observed, but even repeated sample attempts did not yield material, because hard rocks prevented the grab to close completely.
On August 1st grab GTVB was repaired and for the first time reached bootom. The collected material, however, was washed out during hoisting. Later on, using the closed TV grab GTVA at station 68 it turned out that the friable material was a mixture of Mn/Fe oxides and iron smectites which is frequently associated with the sulphides. In addition to Location B, also the old "Alvin" 1001 site, named location A, was revisited and sampling attempts were made. At this place sediment cover easily produces clouds of suspended matter which makes the recognition of the rocks difficult. Some of the sulphide samples of location B proved to be very metal-rich, e.g. station 42 GTVC averaged 32 % Zn, station 50 GTVC 26 % Zn.
Station 41 GTVC, on August 5, was the first yielding more than 1 ton of sulphides, which corresponded to the total recovery of the GARIMAS 1 cruise.
At the end of cruise leg 2 on August 12 about 5.3 tons of sulphide had been collected. During the leg technical approvements could be achieved at several places. E.g., starting with station 67 the positions of ship and grab could be displayed on a computer screen.
From August 13 to 14 SONNE was in Manta, Ecuador, for crew and equipment transfer. The most important new gear was the TV-photo sledge OFOS. Two people (Herzig, Becker) of Aachen University boarded to commence x-ray analysis on board. The Ecuadorian navy sent C. Moncayo and INEMIN (Instituto Ecuadoriano de Mineria) G. Herrera. 150 tons of fuel could be loaded as well.
Leg 3 was essentially devoted to the prospecting of new areas west of 86°, employing Seabeam and SBP mapping, sediment coring and TV-photo surveying. On August 16, at station 72 GK, 12 km south of the rift axis, near 87°W, an important hydrothermal field was found, similar to the known hydrothermal mounds south of the axis near 86°.

Photo profile 137 later on showed a great number of low hills marked by manganese precipitations within a deepsea plain area.
On August 18, station 76, the first OFOS profile was run. There were still some technical defects, but station 78, next day, yielded excellent colour slides of the neo-volcanic zone at 94°49'W.
Near 95° an area with recent hydrothermal activity found during GARIMAS 1, was re-visited. Abundant smectite precipitations on fresh nodular lava and many elements of the vent fauna were found, but not actual vents. During station 92 FSO, on August 24, dense clouds of suspended matter were encountered near the northern slope of the rift valley. But a subsequent and later research for the origin was unsuccessful.
On August 25 at station 93 D a dredge and a pinger went lost.
After running a few prospecting lines within the de Steiguer Deep, SONNE headed east again and on August 27 reached the Galapagos Fracture Zone. A photo-TV-station (97) was run down the steep slopes of the main fault, but the prevailing talus terrain showed no hydrothermal indications. On August 29 SONNE was back in the Atnav-array to sample additional sulphides. Before heading for Manta, a last TV-photo station (110) was run near the northern slope of the rift valley, and an interesting new hydrothermal field (location C) was found. There were many small chimneys, some looking rather fresh. Though resembling sulphide structures, sampling during the next cruise leg showed that they are entirely composed of silica. This was a new type of hydrothermal field, never seen before on the ocean floor.
From September 2 to 3 SONNE was in Manta again, where some crew exchange took place. Among the newcomers were the Ecuadorian scientists Viteri and Rada and two female scientists (Wilke and Speich).
Leg 4 operation started again in the Atnav array area, which was extended by 2 transponders to allow detail work at location C and further east. Sulphide sampling at location B continued as well, leading to a huge (1800 kg) block at station 121, which averaged 30 % Fe, 3.16 % Cu and 8.9 % Zn. However, the biggest piece of sulphide, ever obtained from the ocean floor, was lifted on September 9 at station 126. The exact weight, determinated later on land, was 3347 kg.
On September 11 SONNE headed west to continue prospecting of the rift axis, mainly by alternating Seabeam/SBP profiling and visual observation by OFOS. It turned out that the general benthic activity diminishes from east to west.
On the way back to location B the area around 86,5°W was investigated more in detail, and typical vent animals were observed (Bythograea) near the o-age axis.
At location B, photo profiles revealed the existence of hills composed mainly of silicates, in addition to the sulphides.

The last port call in Manta was from September 17 to 18.
Leg 5 started again at locations A to C, but on September 19 the coaxial cable was found to be damaged, and 2,745 m had to be cut off. Meanwhile, SONNE headed further west to continue bathymetric profiling of the axial area.
Cable work was resumed on September 21 with photo station 152 at 91,5°W. Rocks were found powdered with a greenish material which could be tephra or hydrothermal silicates. Similar material was observed on a round volcano at 91°57' (Station 153 FSO). Further search for vents which produced the clouds observed near 95°W was not successful.
The second part of leg 5 was characterized by the cooperation with the American (NOAA) cruise of ATLANTIS II/ALVIN . First wireless contact with the chief scientist Dr. R. Embley was made on September 24. Subsequently, SONNE returned eastward. On September 26, at station 162 FSO sulphides were found in tectonically disturbed lava near the axis at 89°19'W. On September 27 ATLANTIS II arrived at the working area (location A). Next day, both ships met, and Dr. Embley and Dr. Malahoff boarded SONNE to coordinate the two programmes. There were the usual interferences between the different acoustic systems, which could be settled by switching off part of the transponders. ATLANTIS II at first focussed the work at location A while SONNE continued work at and around location B. Station 171 GTVB yielded a big block of very well crystallized sulphides, which had to be protected against souvenir hunters.
Next station (172 FSO) at 85°57' revealed a new hydrothermal site showing small chimneys of concretionary manganese.
On September 30 a television team from the WDR (West German Broadcasting) boarded from A II.
There was a crew exchange nearly every day, and a continuous discussion of information obtained by the three ships. On October 2, station 182 FSO, a new important hydrothermal field ("location D") was detected near the northern slope of the rift valley, west of location C.
Next night, an OFOS profile was run along the location A structures in presence of several visitors from A II. The typical, towerlike brecciated and partly mineralized rocks of this site could be recognized. Another visual inspection (191 FSO) of location A was made, together with Dr. Malahoff, on October 4. Next day, a new sulphide location was found ("location E") on the talus covered northern slope of a horst structure which usually was called "duck head", half way between locations A and B.
During these days, several ALVIN dives were carried out at location A. Among other operations magnetic and electric measurements were performed to investigate the

possibility of new exploration methods. For calibration, sulphide cores were delivered to Prof. Francis who designed the electrical equipment. On October 8 A II went to the low-temperature vent fielus at Rosegarden (86°08'W) for a 3 days TV filming with ALVIN (dives 1657 - 1659).

During that time, SONNE passed to locations A and E for sampling and OFOS-surveying. On October 11 Dr. Malahoff, diving with ALVIN, inspected the silica chimney field of location C. Two days later, during ALVIN dive 1661, Dr. Embley and Dr. Bäcker surveyed the central part of location B. The last discoveries were made on October 13 during OFOS station 225: on a profile cutting the rift valley at 85°58' 3 new hydrothermal sites were found: location F a sulphide site on relatively fresh lava, location G a chimney field resembling very much the silica site C, and location H a major field, possibly composed of silicates and sulphides. Location F was sampled next day (station 228 GTVC), and 1480 kg sulphides were recovered. For the other locations no time was available any more. On the same day ATLANTIS II left for Panama and SONNE for Callao.

The Peruvian port was reached on October 18 in the early morning.

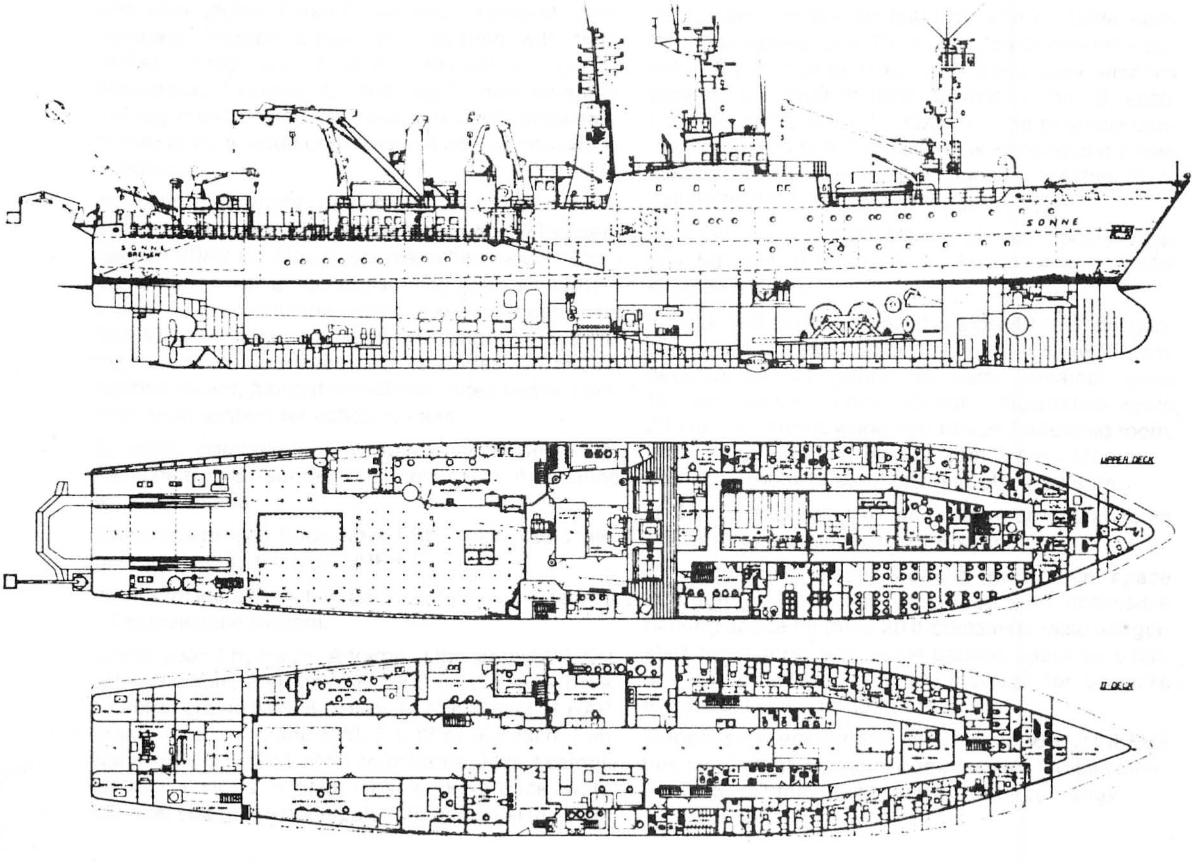
6. RESEARCH VESSEL SONNE

MS SONNE is a specialized research vessel for deepsea mineral exploration and is owned and managed by RF Reedereigemeinschaft Forschungsschiffahrt GmbH in Bremen, a subsidiary company of Metallgesellschaft AG and Preussag AG. Technical details are listed in the Table below.

During cruise SO 39 the ship was mainly used for sampling of massive sulphides with three different types of TV-controlled electro-hydraulic grabs, for bathymetric profiling (Seabeam, ELAC NSB echo sounder, 3,5 kHz SBP), for deep-towing (specially photo-TV-sledge), dredging, coring and hydrological measurements. Dredging was done on the starboard side using the fishing winches, sledge towing and heavy grab sampling via the A-frame at the stern, using the friction winch, and hydrological work on the port side, using the hydrographic cable winch.

During the cruise there were no major breakdowns of the ship's equipment effecting the program performance. Towards the end of the cruise, increasing troubles were encountered with the 18 mm coaxial tow cable. Some minor instrument failures caused only 16 hours down-time. This is less than 0.6 % of the entire GARIMAS 2 ship time.

RV SONNE, technical details



Flag: Federal Republic of Germany.

Port of registration: Bremen.

Call sign: DFCG.

Classification: GL + 100 A4 EF + MC.

Owners: Partenreederei MS SONNE.

Managing owners: RF Reedereigemeinschaft Forschungsschiffahrt GmbH, August-Bebel-Allee 1, D-2800 Bremen 41, Tel.: (421) 232059, Telefax: (421) 239462, Telex: 246062 rfor d.

Built: 1969, as stern-fishing trawler at Rickmers Werft, Bremerhaven, converted 1977 at Schichau Unterweser AG, Bremerhaven and 1978 at Rickmers Werft, Bremerhaven.

Basic dimensions: GRT: 2607, NRT: 1263, Displacement: 3834 t, Length o.a.: 86.81 m, Length p.p.: 76.20 m, Beam 14.2 m, Draught: max. 6.50 m, Depth main deck: 9.30 m, Service speed: 13 kn.

Personnel: Crew: 26, Scientists: 23.

Main engine: 4 x MaK 8 M 281 AK – 4x735 kW.

Propulsion: 2 x BBC-propulsion motors. 2 x 1100 kW.

Manoeuvring propulsion devices: Escher Wyss variable pitch propeller, bowthruster 588 kW, 10 t thrust. Special rudder with flap.

Generators: 4 x BBC, 4 x 810 kVA, 380 V, 50 c.

Ship's network: 380 V, 50 c; 220 V, 50 c by transformator.

Stabilized network: 380/220 V, 50 c, voltage stab. ±1%, frequency: stab. ±0.5%, dynamic ±1.2%, 40 kVA total.

All living rooms and laboratories are fully air conditioned.

Bunker capacity: 920 t gasoil, 50 t fresh water, fresh water production 30 t/day.

Consumption: 10 t gas oil/day at service speed.

Maximum service duration: 90 days.

Sewage treatment, oil seperator.

Navigation: 3 radars, direction finder, Decca navigator with track plotter, Loran-C-navigator, autopilot, gyrocompass, Nautomat-navigation system with track plotter, integrated satellite navigation system Magnavox, 2xLoran C micrologic, doppler-sonar, EM-log, monitors and teletypes, satellite/Omega navigation system, additional master's control near working area.

Acoustic equipment: bathymetric multi-beam-sonar system Sea-Beam, Elac NSB echo sounder 3 frequencies 30/20/12 kc, Elac deep sea-echosounder (ENIF) combination with pinger registration 12 kc, subbottom profiler, 3.5 kc, shallow water survey echosounder 30/210 kc, acoustic transponder navigation system, depth indicator, horizontal echosounder, fish finding echosounders, navigation echosounder, heave compensation system for echosounders.

Scientific equipment: x-ray spectrometer, deep sea-TV-system, XBT-sonde, comprehensive measuring instrumentation.

Radio equipment: Short wave SSB 1.6 kW, radio telephony, wireless teletype, VHF.

Intercom: telephone, talk-back-system, walky-talkies, TV-surveillance system.

Lifting gear: 1 hydraulic A-frame at the stern, SWL 12 t, 125° slewable, 2 cranes AK 6000 on the work deck, 1 central crane, SWL 8 t, max. 14 m outreach, 1 HAP-crane, 1 derrick crane SWL 5 t, 12 m outreach, 1 jib-boom up to 3 m, SWL 10 t, 1 corer frame, 24 m, 1 sample lift with 4 stops in hold, labs, working deck, water sampler station, 1 working platform (dolly) at the stern.

Winches: 1 Deep tow winch, electro-hydraulic with 2 storage winches for 8000 m rope or cable each 18 mm Ø, speed up to 120 m/min, "slack-line-take-up" and "wave compensator", 2 deep sea winches (spares) for 7000 m rope, 12 and 18 mm Ø, each, 1 hydrographic winch for 6000 m rope or single conductor cable, 4 to 8 mm Ø, various working and auxiliary winches, 3 measuring systems for winches (controlling tension, speed and length).

Laboratories (379 sqm) Main deck: geological laboratory 58 sqm, mechanical workshop 14 sqm, water sampler station.

II. Deck: wet geochemical laboratory 42 sqm, dry geochemical laboratory 38 sqm, chemical store 10 sqm, geophysical laboratory 35 sqm, streamer store 15 sqm, seismic store 30 sqm, registration room 20 sqm, electronic workshop 13 sqm, mounting room, gravimetry/magnetic lab 30 sqm, photo laboratory and copy room 17 sqm, drawing office 22 sqm.

III. Deck: gravimeter room 13 sqm, computer room 14 sqm, echo sounder room 8 sqm.

Handling/work space: working deck, free space 220 sqm, II. Deck: free space 200 sqm, accessible parking space for three 20 ft-containers (also refrigerated containers), accessible parking space for 5 laboratory containers on deck, stowage for scientific equipment 145 sqm (320 m³).

Geophysical equipment: (for seismic) 6 x JUNKERS free piston high pressure compressors 150 bar, delivery 2.05 m³/min each, slipway for airgun array.

RF Reedereigemeinschaft
Forschungsschiffahrt GmbH · Bremen
August-Bebel-Allee 1 · D-2800 Bremen 41
Phone (421) 232059 · Telex 246062 · Telefax (421) 239462

7. NAVIGATION

Throughout the cruise the positioning of the ship was based mainly on Transit Satellite Navigation and with reservations on GPS Satellite Navigation, operated by the Institut für Erdmessungen der Universität Hannover.

During the stationary work the satellite Navigation has been supported by Acoustic Transponder Navigation (ATNAV). For this task supplementary a new acoustic navigation system for determining the position of deeptowed equipment was employed, the RS/904.

Finally the multibeam echosounder SEABEAM was an undispensable tool when exploring for new sulfide deposits.

7.1 TRANSIT Satellite Navigation

The TRANSIT satellite system consists of five to six satellites in polar orbit. Each satellite continually transmits on the two frequencies 400 and 150 MHz and on each carrier the orbital information of that particular satellite is impressed. While measuring the doppler shifts of the two frequencies of the moving satellite during the visible time of 15 to 20 minutes, the integrated computer of the Magnavox Satellite Navigation System calculates the position of the ship by means of the dead reckoned ship's position. This position has been determined continually between the two satellite fixes by recording the ship's speed by Doppler Sonar and the ship's heading by gyro.

The accuracy of the ship's position can be estimated from the offsets between a satellite fix and its dead reckoned position. To do this for a number of 107 fixes the means of the offsets in latitude and longitude were measured.

For the Galapagos Rift Area W 86 the following values have been observed:

observation period	01.august.1986 13:17 - 16.august.1986 22:05
number of uptdated fixes	108
fix rate	1 fix/183 min
mean offsets	latitude 1.052 km
	longitude 1.981 km.

In comparison to earlier cruises the offsets are relatively large. The reason for this is the low fix rate caused by failure of one of the six satellites. Moreover, during the observation period nearly only stationary work with low ship's speed, resulting in high Doppler Sonar velocity errors, was done. Having applied the standard correction on the couple positions a medium error of roughly 1 km in longitude and 0.5 - 1.0 km in latitude remains.

This estimation corresponds to the results which were obtained from several comparisons of TRANSIT, GPS and ATNAV data.

7.2 NAVSTAR GPS Navigation

When fully operational (planned 1989) the NAVSTAR GPS Satellite System will consist of 18 satellites orbiting the earth every 12 hours, beaming down a continuous stream of coded time and orbital position (almanac) information. Several monitoring control stations scattered across the globe will track the SVs, transmit information to them and control the timing and content of SV navigation messages. The user with the receiving equipment can tap the stream of data and decode it. Since all NAVSTAR SVs indicate the time they begin broadcasting their individually coded messages, the receiver set measures the exact time each signal is received and computes the time difference between transmission and measurement. Data from several SVs and the orbital element (position) data of the SVs are then used to calculate precisely the position of the user in three dimensions, along with precise time.

Although the satellite network is incomplete thus limiting coverage times it can be used in a limited capacity by the TI 4100 NAVSTAR Navigator, which was installed on Board RV SONNE.

The precise atomic rubidium frequency standard of the MAGNAVOX assembly had been connected to the TI 4100.

Optimum use of the NAVSTAR receiver is provided by four distinct modes of operation:

(1) Four-Satellite navigation

(2) Three-Satellite altitude hold navigation when nearly constant mean sea level (MSL) altitude can be maintained

(3) Three-Satellite time bias rate - hold navigation providing an unconstrained three-dimensional position solution, whenever a precision atomic frequency standard is in use.

(4) Two-Satellite navigation whenever constant altitude can be maintained and a precise atomic frequency standard is used.

The NAVSTAR receiver yields navigation solutions in all 4 different modes of an accuracy of 10 - 20 meters.
During the cruise 8 satellites were in orbit, two of them (SV numbers 4 and 7) were "unhealthy" and thus not available for navigation.

TABLE 7.1 displays roughly hours, when GPS - navigation data could be obtained.

Week from to	Data coverage from to	Satellite numbers
24.07.85 - 30.07.85	20:30 - 07:10	6, 8, 9, 11, 12, 13
31.07.85 - 06.08.85	20:50 - 08:00	6, 8, 9, 11, 12, 13
07.08.85 - 13.08.85	19:40 - 07:15	6, 8, 9, 11, 12, 13
14.08.85 - 20.08.85	19:30 - 06:30	6, 8, 9, 11, 12, 13
21.08.85 - 27.08.85	19:00 - 06:15	6, 8, 9, 11, 12, 13
28.08.85 - 03.09.85	18:30 - 06:50	6, 8, 9, 11, 12, 13
04.09.85 - 10.09.85	18:10 - 06:30	6, 8, 9, 11, 12, 13
11.09.85 - 17.09.85	17:25 - 05:50	6, 8, 9, 11, 12, 13
18.09.85 - 24.09.85	16:30 - 04:30	6, 8, 9, 11, 12, 13
25.09.85 - 01.10.85	16:25 - 04:30	6, 8, 9, 11, 12, 13
02.10.85 - 08.10.85	15:50 - 03:55	6, 8, 9, 11, 12, 13
09.10.85 - 15.10.85	15:50 - 03:10	6, 8, 9, 11, 12, 13

For further information see ANNEX I.

Due to the excellent quality and very high accuracy of the GPS-data it was possible to determine the accuracy of TRANSIT fixes on sea. Only "2D-Update" fixes (not hand updated) exhibiting elevations greater than 15 and lower than 75 degrees were chosen for this comparison. During the time period 01. Aug. 85 - 31. Aug. 85 a number of 153 2D-fixes were observed.

Fig. 7.1 displays the result of the comparison. The center of the coordinate system represents the GPS position. The dots show the position of the TRANSIT fixes. The average distance of the TRANSIT fixes from the GPS position amount to 94.73 m and is shown by the inner circle in Fig. 7.1. With a probability of 96.7 % all TRANSIT fixes lie inside of a 200 m circle.

Taking into account the position error of GPS (10 - 20 m) we can estimate the average deviation of 2D TRANSIT fixes from the real position to be roughly 100 m. This standard deviation is roughly three times as large as the observation of stationary recorded fixes on land show, when the observer's position is known. The average accuracy of the latter amount to roughly 35 m.

The good quality and high accuracy of the GPS navigation was very advantageous to map the SEABEAM charts. The level adjustment in position of plotted SEABEAM profile strips for adjacent GPS profiles was - if at all necessary - according to the accuracy of the SEABEAM system 50 - 80 m. When correcting the navigation error of TRANSIT sailed profiles, level adjustments in position of up to 1 km had to be carried out! Here the GPS navigated tracks could be used as a reference.

Finally the GPS data were useful for quick calibration of the ATNAV array in an geographic coordinate system. Moreover, it was possible to control the quality of the ATNAV ship positions.

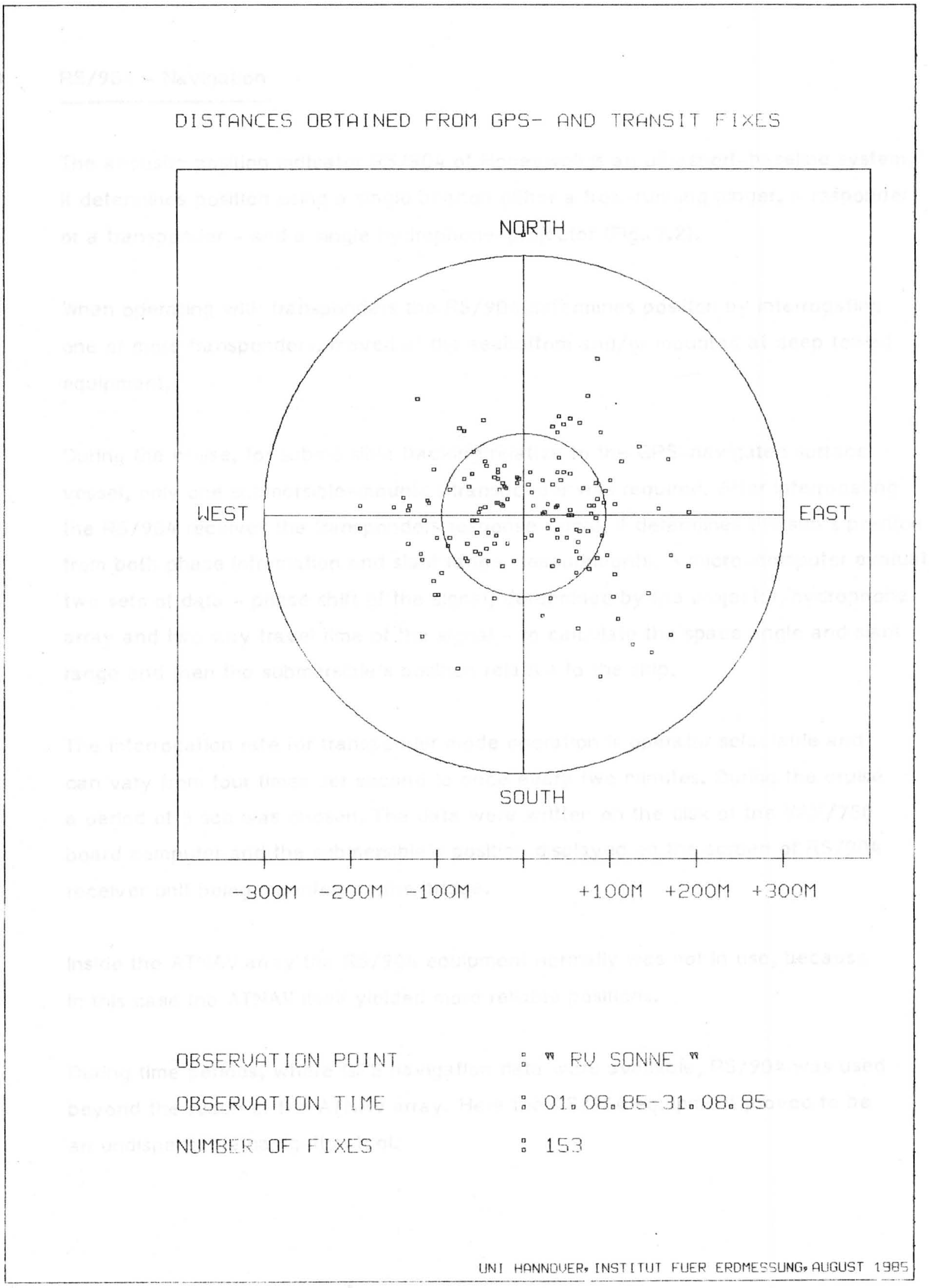


FIG. 7.1: COMPARISON OF GPS AND TRANSIT FIXES

7.3 RS/904 - Navigation

The acoustic position indicator RS/904 of Honeywell is an ultrashort-baseline system. It determines position using a single beacon either a free-running pinger, a responder or a transponder - and a single hydrophone-projector (Fig. 7.2).

When operating with transponders the RS/904 determines position by interrogating one or more transponders, moved at the seabottom and/or mounted at deep towed equipment.

During the cruise, for submersible tracking relative to the GPS-navigated surface vessel, only one submersible-mounted transponder was required. After interrogating the RS/904 receives the transponders response signal, it determines the sub's position from both phase information and slant range measurements. A micro-computer evaluates two sets of data - phase shift of the signal, determined by the projector/hydrophone array and two way travel time of the signal - to calculate the space angle and slant range and then the submersible's position relative to the ship.

The interrogation rate for transponder mode operation is operator selectable and can vary from four times per second to once every two minutes. During the cruise a period of 3 sec was chosen. The data were written on the disk of the VAX/750 board computer and the submersible's position displayed on the screen of RS/904 receiver unit being mounted on the bridge.

Inside the ATNAV array the RS/904 equipment normally was not in use, because in this case the ATNAV itself yielded more reliable positions.

During time periods, where GPS navigation data were available, RS/904 was used beyond the reach of the ATNAV array. Here the RS/904 equipment proved to be an undispensable navigation tool.

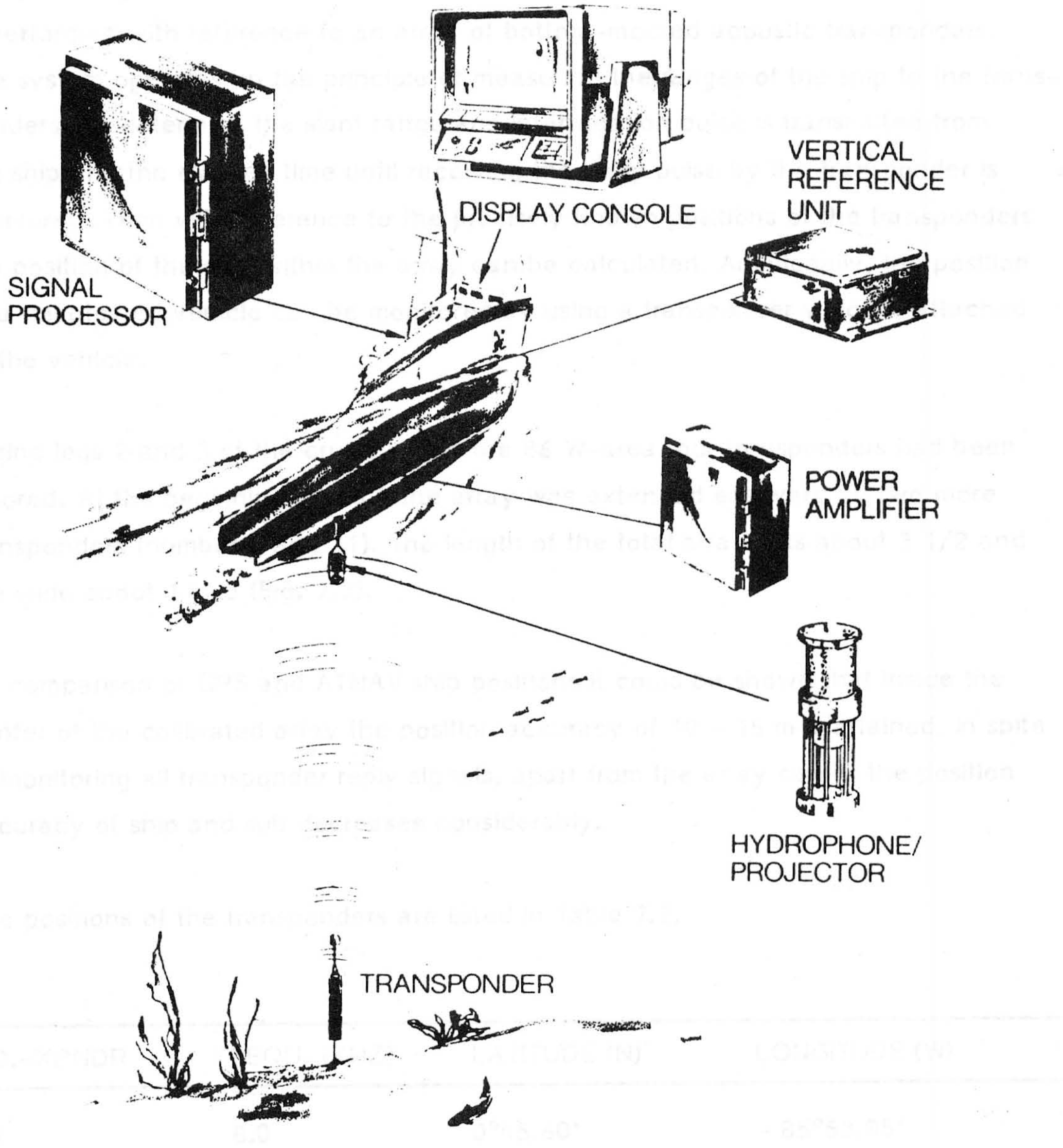


FIG. 7.2: Typical RS/904 Equipment Configuration on a Support Vessel

7.4 ATNAV Transponder Navigation

Another navigation system used in the Galapagos Rift area was the Acoustic Transponder Navigation System ATNAV II manufactured by AMF SeaLink/EG+G. Here the positioning is performed with reference to an array of bottom-moored acoustic transponders. The system operates on the principle of measuring the ranges of the ship to the transponders. To determine the slant range and interrogation pulse is transmitted from the ship and the elapsed time until receiving the reply pulse by the transponder is measured. Then with reference to the precisely known positions of the transponders the position of the ship within the array can be calculated. Additionally, the position of a deeptowed vehicle can be monitored by using a transponder which is attached to the vehicle.

During legs 2 and 3 of the cruise within the 86 W-area four transponders had been moored. At the beginning of leg 4 the array was extended eastward by two more transponders (number 0 and 11). The length of the total array was about 3 1/2 and the wide about 1 mile (Fig. 7.3).

By comparison of GPS and ATNAV ship positions it could be shown that inside the center of the calibrated array the position accuracy of 10 - 15 m is attained. In spite of monitoring all transponder reply signals, apart from the array center the position accuracy of ship and sub decreases considerably.

The positions of the transponders are listed in Table 7.2.

NO.-XPNDR	FREQU. (KHZ)	LATITUDE (N)	LONGITUDE (W)
1	8.0	0°45.60'	- 85°53.85'
2	8.5	0°45.80'	- 85°55.68'
4	9.5	0°46.75'	- 85°55.96'
6	10.5	0°46.55'	- 85°54.81'
0	7.5	0°46.67'	- 85°53.15'
11	13.0	0°45.82'	- 85°52.65'

TAB. 7.2 POSITION OF TRANSPONDERS

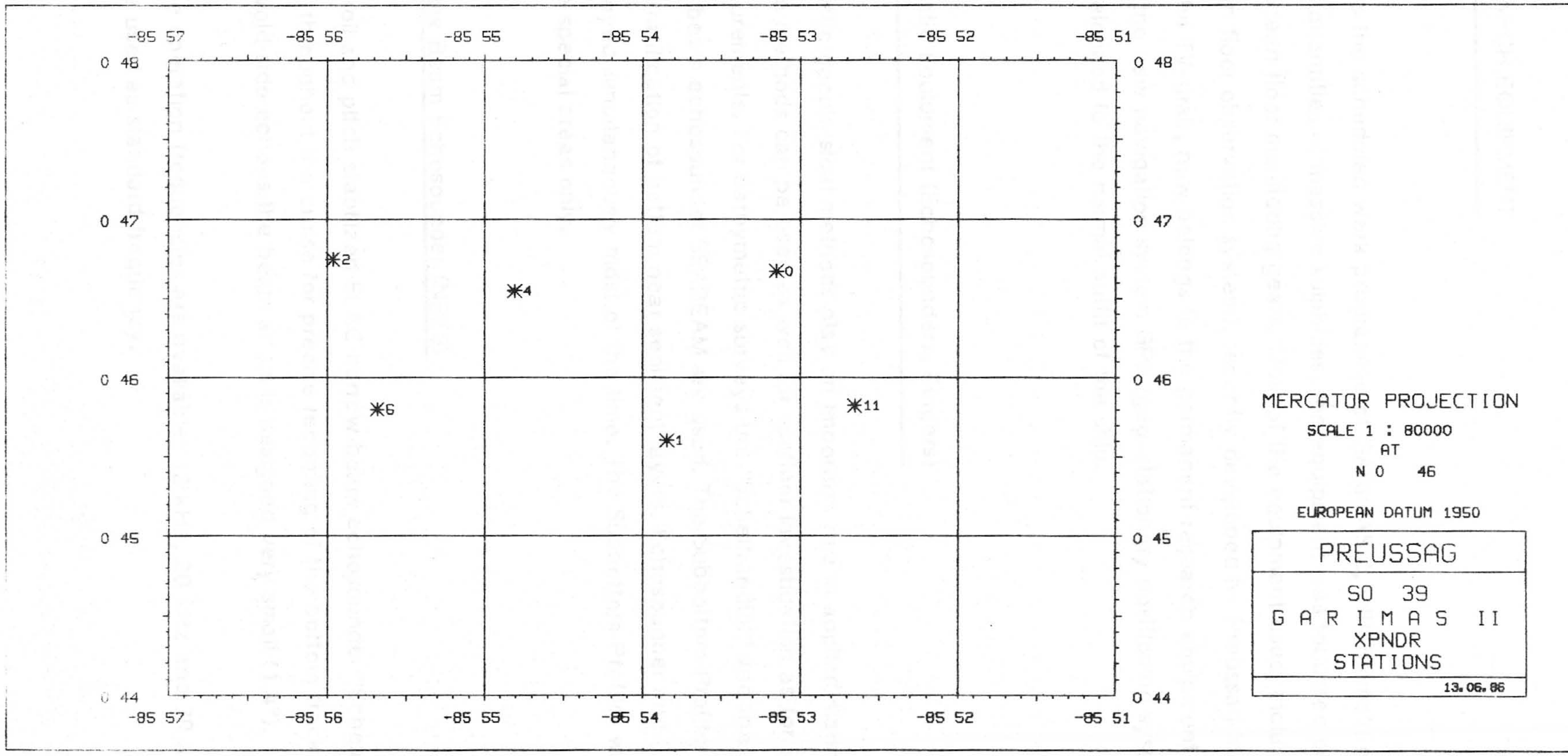


FIG. 7.3: ATNAV-TRANSPONDER STATIONS DURING SONNE CRUISE 39 (1985)

8. RESEARCH EQUIPMENT

Due to the scheduled work programme of GARIMAS 2, with its main goal to sample major quantities of massive sulphides, the equipment was focussed on sampling and ocean floor monitoring gears. Most of the equipment used, including the OFOS (ocean floor observation system), recently developed by Preussag Marine Technology, and the TV-grab, now belongs to the permanent research equipment of R/V SONNE. Only the new navigation system GPS (geo-stationary positioning system) has not yet belonged to the normal outfit of the ship.

8.1 Acoustic Equipment (Echosounders, Pingers)

Acoustic geophysical methods play an important role in applied marine research. These methods can be used as well for seafloor investigation as for subbottom measurements. For bathymetric surveys the "Schelfrandlot" and the newly acquired multi beam echosounder SEABEAM are used. The Subbottom Profiler explores the stratification of bottom near sediment layers. Echosounder and SEABEAM were employed simultaneously most of the time. The Subbottom Profiler was in use for some special areas only.

8.1.1 Narrow Beam Echosounder (NBES)

The roll and pitch stabilized ELAC narrow beam echosounder "Schelfrandlot" was used throughout the cruise for precise recording of the bottom track. In order - to avoid side echoes the beam angle is designed very small (1.4°).

Three operation frequencies are available: 12 kHz, 20 kHz and 30 kHz. 20 kHz were used as standard frequency.

In order to avoid disturbances of the acoustic transponder navigation system (working in a range of 7.5 kHz to 15 kHz) the system was switched during ATNAV operation to 30 kHz. The depth data of the NBES are recorded on the MAGNAVOX data tapes, available for later access.

8.1.2 Seabeam System

The ocean bottom topography was mapped with the multibeam echosounder "SEA-BEAM" which is a product of General Instrument Corp./USA. The system insonifies continuously the seafloor with a signal of about 12 kHz frequency. The bottom reflected signal is detected by a set of hydrophones and then electronically formed into 16 beams. As a first result all 16 beams are displayed on a monitor showing a bathymetric cross section of the ocean bottom athwart ship. With each shot - at 3,000 m water depth every 4 seconds - a new cross section updates the monitor.

Simultaneously the depth information is fed into a computer and with additional ship's velocity information a strip chart is processed showing contour lines of the water depth. The width of the strip map depends on the water depth and amounts to about 80 % of the depth. The 16 water depths of each channel and the timer are written also on magnetic tape, available for later postprocessing.

8.1.3 Subbottom profiler

The 3.5 kHz Subbottom profiler was in use only for some selected areas. The device used was an O.R.E. type consisting of a hull-mounted array of 16 transducers, a transceiver unit and an EPC-Graphic Recorder.

Because of the relatively low working frequency echoes from below the seabed can be recorded.

The quality of the recordings was pure due to the rough topography of the spreading centre and its vicinity. In spite of a great number of side echoes disturbing the data, the presence of sediment structures could be observed in many cases.

8.2 Oceanographic Equipment

The oceanographic instruments mainly used during GARIMAS 2 were the multi-sensing deep sea probe Multisonde and a rosette sampler which was equipped with twelve bottles. Additionally, a bottom-moored savonius-type currentmeter recorded the bottom-near currents over the whole period of the ship's presence in the Galapagos Rift working area.

The Multisonde of ME Meerestechnik-Elektronik, Trappenkamp, is a high-precision multi-sensing STD-probe, which provides the opportunity to gather fast and simultaneous information about the vertical and horizontal distribution of a great number of differerent hydrophysical and -chemical parameters (see Tab. 8.2.1). Beside the parameters listed in Tab. 8.2.1 the salinity is on-line calculated from the pressure, temperature and conductivity readings applying the recently developed so-called "UNESCO-Formula". The Multisonde is a versatile measuring instrument capable to monitor up to 32 different parameters.
The system consists of two parts - the underwater measuring unit and the board unit. The underwater unit is equipped with six different probes and is tested for a water depth down to 6,000 m. The unit is designed to measure preferably continuous vertical profiles, but, mounted in a deep towed vehicle, it is also capable to measure horizontal profiles. The underwater unit is connected to the board unit via a hydrographic winch and a 8 mm diameter coaxial cable. The board unit displays all parameters and provides three analogue outputs for on-line graphic recording. The digital output is recorded on magnetic tape and additionally quasi on-line plotted on a computer graphic screen. Hard copies of the bottom-near sections of these on-line plots are compiled in Annex 2.
Last not least the Multisonde provides the possibility to trigger twelve release mechanisms mounted in a rosette water sampler.

Water sampling during the GARIMAS cruise was carried out using the rosette water sampler triggered via the Multisonde. The electric-mechanical release mechanisms mounted in the rosette sampler were tested for water depths down to 6,000 m. The rosette sampler was equipped with ten plastic water samplers of the Niskin type, each capable to recover 5 liters of sea water. The Niskin water sampler features all plastic construction with a free flushing design by large inlets. The sampling tube is completely metal-free. Four of the mounted samplers were supplied

6

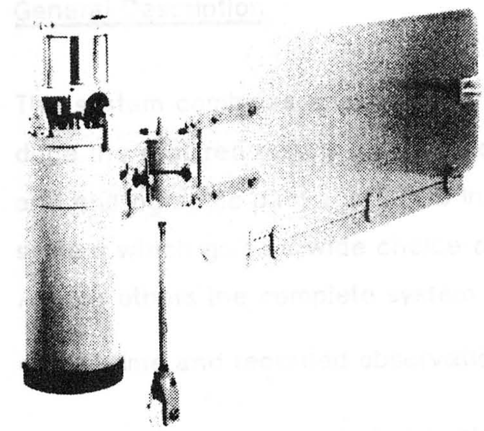
with a triple thermometer tube for three thermometers. Each of the thermometer tubes was equipped with 2 reversal thermometers.

Current measurements above the seafloor were carried out with an "Aanderaa RCM 5", which is a cycle counting "Savonius" rotor type current meter. The RCM 5 is a self-recording instrument. It is pressure-proved to a water depth of 6,000 m. Depending on the measuring interval the recording and battery capacity reaches up to 2 years. More technical data are presented in Table 8.2.2.

TAB. 8.2.1: TECHNICAL DATA OF MULTISONDE PROBES

	Pressure	Temperature	Conductivity	Diss.Oxygen	Light Attenuation	Sound Velocity
Physical unit	d bar	°C	mmho/cm	% O_2	a/m	m/sec
Principle of measurement	piezo resistive	platinum resistance	symmetric electrode cell	membran covered multi microcathode	light attenuation	wave oscillator with constant wave length
Meas. range	0-6000 dbar	-2 - +32°C	0-60 mmho/cm	0-150% O_2	0-94%/m	1400-1600 m/sc
Resolution	0.1 dbar	0.001°C	0.001 mmho/cm	0.1% O_2	0.01 %/m	0.015/m/sec
Accuracy	± 2.5 %o	± 0.005°C	± 0.01 mmho/cm	1% O_2	± 0.1 %/m	±0.04 m/sc
Time constant of probe	-	60 msec.	50 msec.	60 sec.	50 msec.	10 msec.
Duration of one single measurement	2 msec	2 msec	2 msec	-	2 msec	2 msec
Max. working depth	6000 m	6 000 m	6000 m	6000 m	6000 m	6000 m
Remarks	3 different measuring ranges are available	2 different types are available	2 different ranges are available	output is also in mg/l available	the length of light path is selectable	the measuring range is selectable

TAB. 8.2.2: TECHNICAL SPECIFICATIONS OF CURRENTMETER AANDERAA RCM 5



TELEMETRY:
Acoustically:
By switching on and off carrier from acoustic transducer.
Frequency: 16,384 KHz ± 5 Hz.
Detection Range: Typically 800 meters with *Hydrophone Receiver 2247*.
By Cable:
5 volts negative, short and long pulses from terminal on top endplate. May be used for real time readings and for calibration purposes by use of *Printer* 2860.

POWER:
Battery: 9 volts, non-magnetic. Leclanche 821
Size: 63 x 50 x 80 mm.
Capacity: sufficient for 10,000 samplings.

MOORING:
Spindle designed for 15 mm. maximum diameter rope. Gimbal mounting permits 27^o deviation between spindle and instrument

SPECIFICATIONS

MEASURING SYSTEM:
Self balancing bridge with sequential measuring of six channels and recording on magnetic tape. A ten bit binary word is used for each channel.
Measuring Speed: 4 seconds each channel.
The channels are:

1. REFERENCE:
This is a fixed reading that acts as a control on the performance of the *RCM*, and also as an identification of individual instruments.

2. TEMPERATURE:
Sensor Type: Thermistor (Fenwal GB32JM19)
Ranges:
Low Range: -2.46^oC to 21.40^oC (standard).
High Range: 10.08^oC to 36.00^oC.
Wide Range: -0.34^oC to 32.17^oC.
Accuracy: $\pm 0.05^oC$.
Resolution: 0.1% of range selected.
63% Responce Time: 12 seconds.

3. CONDUCTIVITY: (optional)
Sensor Type: Inductive cell.
Ranges: 0 – 77 mmho/cm., (standard).
25 – 72 mmho/cm
25 – 38 mmho/cm
Resolution: 0.1% of range.
Calibration Accuracy: ± 0,025 mmho/cm

4. PRESSURE: (optional)
Sensor Type: Bourdon tube driving a potentiometer.
Ranges: 0-100 PSI, 0-200 PSI, 0-500 PSI, 0-1000 PSI, 0-3000 PSI, and 0-9000 PSI. 0-3000 PSI is standard.
0-9000 PSI is available for *RCM5* only.
Accuracy: ± 1% of range.
Resolution: 0.1% of range.

5. CURRENT DIRECTION:
Sensor Type: Magnetic compass with needle clamped on to potentiometer ring.
Resolution: 0.35^o.
Accuracy: ± $7,5^oC$ for current speed within 2,5 to 5 cm/sec., or 100 to 200 cm/sec.
± 5^o for speed within 5 to 100 cm/sec.
Maximum Compass Tilt: 12^o from horizontal.

6. CURRENT SPEED:
Principle: Rotor with magnetic coupling through instrument case. The number of rotations during the period between 2 samplings are counted by an electronic counter. This counter has a pre-circuit with a choice between ten dividing factors, suited for sampling intervals from 0,5 to 180 minutes. Standard is 4 rev/count.
Range: 2.5 to 250 cm/sec.
Accuracy: ± 1 cm/sec., or ± 2% of the actual speed, whichever is greater.
Starting Velocity: 2.0 cm/sec.

CLOCK:
Type: Quartz crystal
Accuracy: Better than ± 2 sec/day within 0^oC to 20^oC.
Sampling Intervals: 0.5, 1, 2, 5, 10, 15, 20, 30, 60 and 180 minutes, selected by interval selecting switch.
External Triggering: For calibration purposes, a six volts positive pulse to terminal on top end plate will activate the instrument.

RECORDING SYSTEM:
Type: Reel to reel 1/4 inch magnetic tape.
Coding: 10 bit binary words (short and long pulses) in serial form.
Storage Capacity: 10,000 samplings using 600 feet of magnetic tape on 3 inch reels.

EXTERNAL MATERIALS:
Pressure Case: Cu Ni Si alloy (OSNISIL) and stainless acid proof steel. Epoxy coated.
Vane: 8 mm PVC plastic.
Other plastic parts: Polyamid & Polystyrene.
Other metal parts: Stainless acid proof steel and nickel plated bronze. Epoxy coated.

		RCM4	RCM5
DEPTH CAPABILITY:		2000m	6000m
NET WEIGHT:			
Recording Unit,	in air	13.7kg	15.8kg
	in water	9.2kg	11.0kg
Vane Assembly,	in air	12.9kg	13.4kg
	in water	8.1kg	8.5kg
DIMENSIONS:			
Recording Unit:	height	510mm	535mm
	diameter	128mm	
Overall length		1370mm	
Overall height		750mm	
Vane size		370 x 1000mm	
GROSS WEIGHT:			
Recording Unit		19.1 kg	21.0 kg
Vane Assembly		20.6 kg	21.1 kg

PACKING: (RCM4 & RCM5)
Recording Unit:
Plywood Case 190x230x610mm
Vane Assembly:
Plywood Case 155x400x1020 mm

SPARES:
A set of recommended spares is delivered with each instrument. (rotor, bearings, o-rings etc.)

WARRANTY:
One year aganist faulty materials and workmanship.

8.3 Visual Equipment (OFOS)

8.3.1 General Description

This system combines a video camera system and a photographic system to produce the required results for visual observation. In addition to the integrated video and photographic package OFOS includes a micro processor based telemetry system which gives a wide choice of control.
Among others the complete system offers the following advantages:

- real time and recorded observation;
- series exposures for photographic tracking of the ocean floor; therefore the photographic system can be actuated by a programmed interval, by bottom contact or by a remote signal transmitted from a board unit;
- auxiliary flash unit gives additional possibility to suit the illumination of the distance to the ocean floor;
- the resulting photographs, time, date and altitude are displayed on the photographs for purposes of interpretation;
- the use of a high sensitivity low light level camera allows applications in low intensity light conditions;
- the real time transmission of the video signal allows to make decisions affecting the exploration work of the underwater observing system;
- by means of a colour TV-camera and an underwater recording unit the recording of a colour video signal is possible;
- the battery unit which is installed in the instrument frame avoids an expensive energy transmission via the deep sea cable;

The overall concept of the OFOS (Fig. 8.3.1) can be divided into the the following five systems:

- photographic system;
- TV-system;
- underwater power supply;
- telemetry and control unit;
- onboard developing system.

All underwater units are mounted on a stainles steel frame (see Fig. 8.3.2) (length: 4.8 m, width: 1.3 m, height: 1.4 m) which is tethered to the ship with an armoured single wire coax tow cable. Battery units which are also mounted on the instrument frame (sledge) provide the underwater components with the required energy. These battery units are a much more economy-priced solution than an equivalent power supply via the tow cable.

8.3.2 Television System

The TV-system is divided into two parts, the colour TV-system including an underwater recorder unit and the low light-level TV-system. The colour TV-system consists of a colour television camera which operates on the PAL colour system and an underwater VHS-recorder unit including a time/date generator. Features of the camera are good resolution and the ability to operate in conditions where the level of scene illumination is low. The underwater recorder unit enables the recording of the colour video signals. This is necessary since the attenuation of a 8.000 m standard tow cable does not allow to transmit the colour video signal to the ship. For illumination of the colour application four 250 W flood lights are available. The heart of the low light-level TV-system is a Silicon Intensified Target (S.I.T.) television camera. This camera is designed for underwater operation at low light-levels. This is advantageous in situations where high levels of suspended particles in the water cause backscatter from intense light sources. The high sensitivity of the camera enables low intensity-light sources to be used and gives therefore the possibility to save energy.

8.3.3 Photographic System

This photographic system is a general purpose instrument proven for use in a variety of deep ocean applications. The camera takes appr. 800 exposures of a 35 mm standard film per loading and appr. 1600 exposures using a thin-base film. A digital data chamber with light emitting diodes displays time, date and altitude (distance to the ocean floor). The altitude is measured by a short-range acoustic sounding device. Each time the camera takes a photo it records the distance in metres to help interpreting the resulting photographs.
The camera is normally used with one standard strobe and companion power packs. The strobe is a fast recycling, high-energy light source. It provides an output of appr. 200 Ws. The flash duration is so short (appr. 1 ms) that under most conditions photographs are sharp, even if the camera or subject is in motion.
The whole system is powered by two battery packs; they supply 28 VDC from re-chargeable nickel-cadmium batteries. A master battery pack controls the triggering of the strobes, as well as actuation of the camera shutter and film drive. An auxiliary battery pack is provided to assure continuous power for the strobes during a deep ocean mission.
There are three possibilities to actuate the system: actuation by a) a programmed interval, b) by a bottom switch and c) by a remote signal.
Controls and adjustments, contained in the programmer portion of the master battery pack, hold the system in a standby condition while lowering to depth; they set the interval between photo frames and adjust the exposure (shutter speed).
Up to four auxiliary high intensity strobes can be added to meet the requirements of a powerful illumination, especially in applications with a high distance to the ocean floor. These separate units allow individual adjustment in order to minimize a "hot spot" usually caused by a single powerful flash unit. The strobes are slaved together by a synchronisation distributor which also controls the power supply for these units. By means of the board unit the strobes can be switched off separately. This provides additional possibility to suit the illumination of the distance to the ocean floor.

8.3.4 Telemetry System

The telemetry system consists of an underwater telemetry unit and a board unit. It fulfils the tasks of bidirectional transmission of control data as well as transmission of a video signal. The micro-processor system allows control of data transmission. By means of this micro-processor system the board unit enables control of the following functions of the units integrated in the instrument frame:

- actuation of the photographic system;
- separate on/off switching of the 4 auxiliary flashes;
- on/off switching of the low light-level camera;
- on/off switching of the colour camera;
- separate on/off switching of the four flood lights;
- switch-over of the video signal transmission to the board unit (low light-level camera or colour camera);
- switch-over of the video recording in the instrument frame (low light-level camera or colour camera);
- remote control of the underwater recorder unit (ON/OFF, STOP, PLAY, REC, PAUSE, REW, FF).

Several return data of the underwater units which are necessary for system control and secure operation are indicated on the board unit. Due to data transmission during the blanking interval of the video signal, the data rate is limited (8 bit every 20 ms bidirectional). However, the system is extendable for transmission of additional data to the board unit (temperature, pressure, altitude etc.).
Additional integration of up to 4 water samplers is also possible.

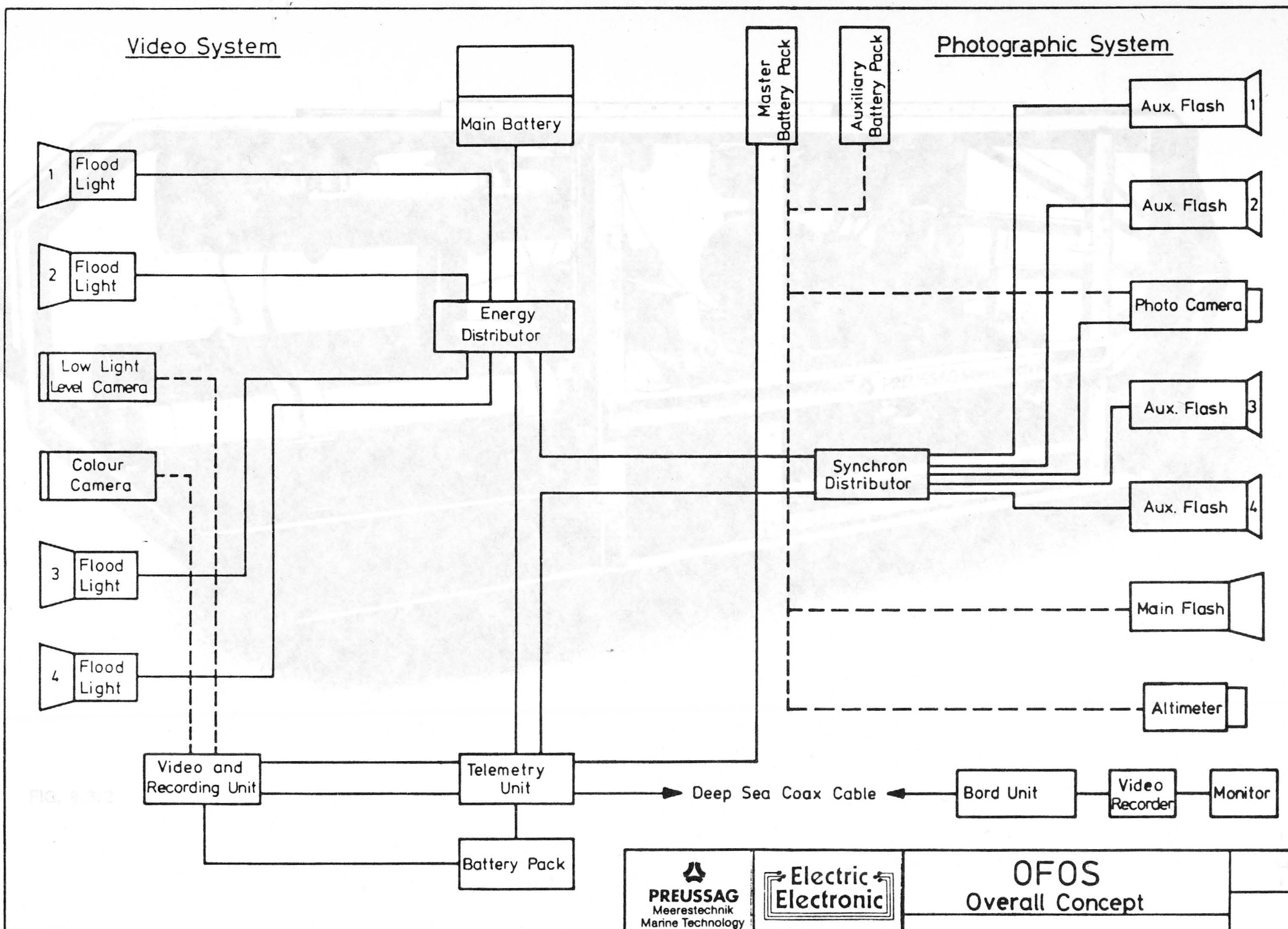
8.3.5 Underwater Power Supply

Various rechargeable battery units matched to the special underwater systems provide the required power. The power for the main loads like flood lights and flashes is provided by the main battery unit. This unit consists of either lead-acid batteries mounted into a pressure housing or two developed lead storage batteries (especially for the use in deep sea applications). These lead storage batteries are pressure-compensated and have a capacity of 230 Ah. The lead-acid batteries, which will be used especially in combination with water samplers, have a capacity of appr. 120 Ah at a discharging current of 40 amperes.

8.3.6 Onboard Developing System

This system is an automatic developing unit with a special marine adaptation for E6 Ektachrome films processing which accept up to 70 mm film sizes. It can easily be operated since it is a completely automatic, dry to dry, self-contained daylight continuous processor. Accurate processing temperatures are controlled without operator involvement and correct developer potency is maintained by an automatic replenisher. The developing system processes films up to a length of 30 m.

FIG. 8.3.1:


Video System
Main Battery
Master Battery Pack
Auxiliary Battery Pack
Photographic System
1 Flood Light
2 Flood Light
Energy Distributor
Low Light Level Camera
Colour Camera
3 Flood Light
4 Flood Light
Aux. Flash 1
Aux. Flash 2
Photo Camera
Aux. Flash 3
Synchron Distributor
Aux. Flash 4
Main Flash
Altimeter
Video and Recording Unit
Telemetry Unit
Deep Sea Coax Cable
Bord Unit
Video Recorder
Monitor
Battery Pack
PREUSSAG
Meerestechnik
Marine Technology
Electric
Electronic
OFOS
Overall Concept

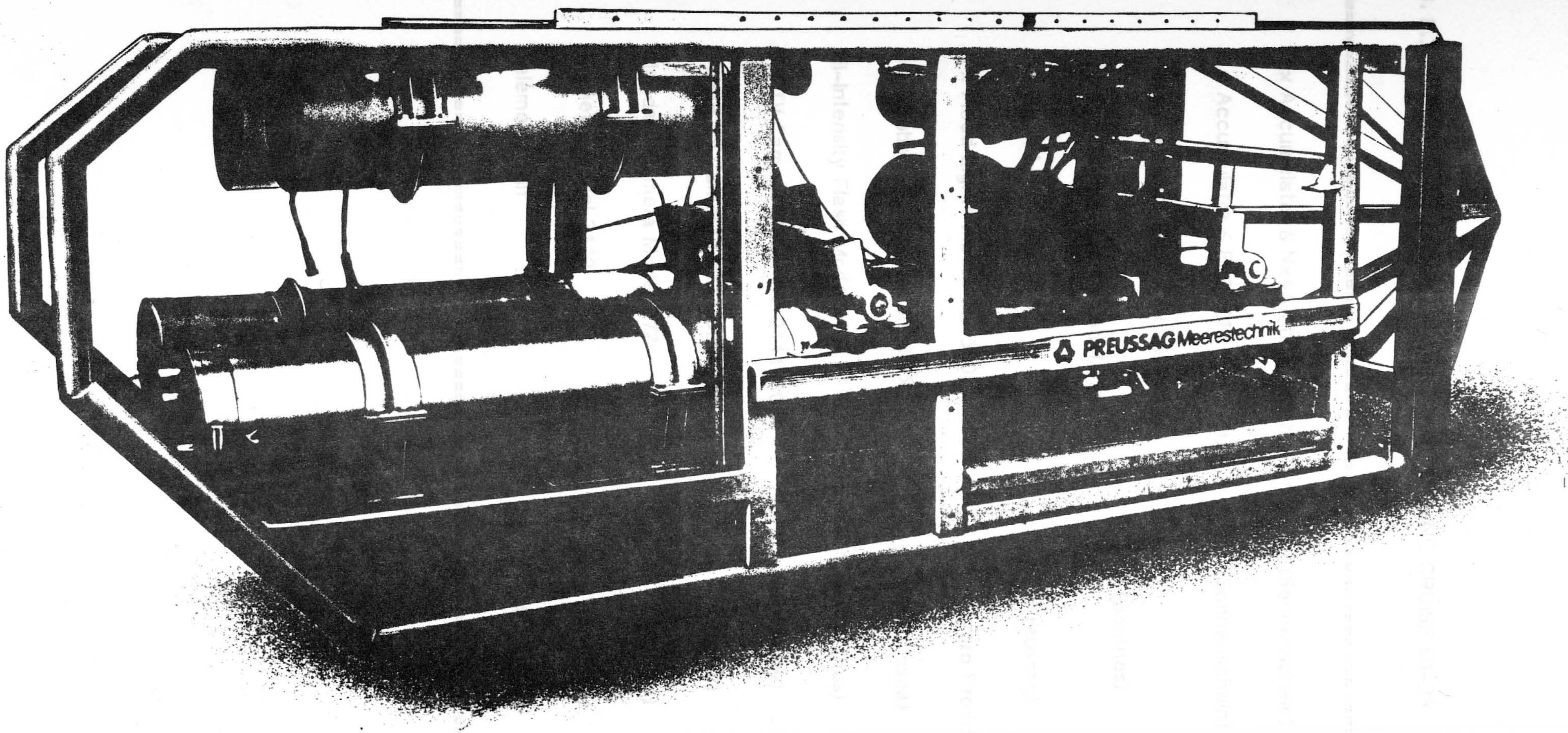


FIG. 8.3.2

TAB. 8.3.1: PHOTO AND TV-EQUIPMENT USED DURING CRUISE SO-39

1.	6 x Accumulator 6 Nx4A (12 V 36 Ah)	(Sonnenschein)
2.	6 x Accumulator 6 Fx5S (12 V 9,5 Ah)	(Sonnenschein)
3.	Storage Battery Pack Model 391)	(Benthos)
4.	Storage Battery Pack Model 329)	
5.	4 x Flood Lights	(Preussag)
6.	2 x Flood Lights Model QL-3000	(Hydro Products)
7.	3 x Strobe Lights Model 3000 SX	(Photosea)
8.	Hi-Intensity Flash Model 383	(Benthos)
9.	SIT TV Camera Model OE 0111-6006	(Osprey)
10.	Colour TV Camera Model OE 1334	(Osprey)
11.	Standard Camera Model 372	(Benthos)
12.	Altimeter Model 2110	(Benthos)
13.	Telemetry unit	(Preussag)

8.4 Bottom Sampling Equipment

8.4.1 Reineck Corer

In order to recover undisturbed surface sediments for geochemical investigations, a conventional box corer of the Reineck type (GK) was used.

The floor space of the stainless steel frame is 280 x 177 cm, the height 230 cm. The net weight of 160 kg can be heightened by means of 10 lead weights of 50 kg each. The cross section of the boxes amounts to 40 x 20 cm, the height 60 cm.

The Reineck corer was handled at the starboard side, using the 18 mm wire of the auxiliary deep sea winch. A pinger mounted 50 m above the corer enabled a controlled bottom approach.

During 24 coring stations no serious problems arose.

8.4.2 Kasten Corer

Once the Kögler's Kasten corer (K) was employed in order to verify the vertial range of hydrothermal influence, noticed before in a GK-surface sample.

A 300 cm corer box with a cross section of 15 x 15 cm was used. The corer was handled at the starboard side, using the 18 mm wire of the auxiliary deepsea winch. A pinger mounted 50 m above the corer enabled a controlled sampling operation.

8.4.3 Dredges

During 21 stations two different chain bag dredges had been employed in order to recover hard rocks as well as massive sulfide material.

The two dredges differ in their dimensions. The larger one (DCB) consists of a 140 x 60 cm rectangular mouth, a thill and a 130 cm long chain bag (40 mm mesh). It went lost on station 93 D during operation.

The dimensions of the smaller one (DCA) are 95 x 50 cm.
The dredge is preceded by a swivel which in turn is connected with the end of the chain bag by a 4 t-safety wire.

In general the dredge was operated at the starboard side of the ship, using the 18 mm wire of the auxiliary deepsea winch. A pinger was mounted 200 m above the dredge.

Commonly the dredge was lowered to the seafloor with the wire in a vertical position while the ship was stopped. After arrival at the seafloor the ship moved apart until the wire was in a 30°-position. Subsequently the movement of the dredge was controlled by the operator, using pinger registration, tensiometer and slave recorder of the 20 kHz NBES.
Apart from the loss of one dredge, only one employment was unsuccessful.

8.4.4 TV-Grab GTVA

This meanwhile approved "Clamshell" was one of the main sampling equipment which especially was constructed to enable a television controlled recovery of massive sulfide deposits as well as undisturbed sediment samples in the deep sea (Fig. 8.4.1).

The construction is extensively protected against upset or overturning. Made of hot galvanized steel and with a white varnish finish, the grab is non-corrosive.
The main dimensions are:

L x W x H (in opened condition)	130 x 200 x 265 cm
L x W X H (in closed condition)	130 x 195 x 315 cm
Weight in air	3.2 t
Weight in water	2.75 t
Base	180 x 110 cm
Capacity	0.6 m^3
Closing power	35 kN
Operation depth	10,000 m

The electro-hydraulic deepsea grab is self-powered by two 12 V pressure-compensated lead-acid accumulators with a capacity of 230 Amp/h and an operation period of max. 8 h. To feasible a good visual inspection of the seafloor with its geological formations, the grab is fitted with an automatically focussing ultra low light wide angle camera, covering an observation area of some 25 m^2, and four lamps, 250 W each, which can be switched individually (two by two floodlight and spotlight). These components are placed symmetrically between the jaws. The remote control is effected by a coaxial cable with bi-directional telemetry. Nine commands permit a great variation in operation, e.g. repeated closing and opening.

The grab was handled over the ship's stern ramp by means of the A-frame, using the 18 mm armoured single wire coax tow cable of the deep tow winch, and then lowered in opened condition. With a speed of approx. 1m/sec the grab moved slowly above the seafloor according to the ship's heading.
Keeping an observation distance of 4 m, which could be controlled by means of a messenger weight hanging vertical below the grab, the operator inspected the seafloor at the grab control console aboard. By use of an electronic keyboard the operator was able to insert pieces of information directly as a commentary into the television picture. The video signal completely with data overlain was then video recorded.

If an interesting geological formation was found, the grab was set down and closed from the operating console. The sampled material was still visible with the grab closed. If the sample was unsatisfactory, the grab was emptied onto the seafloor and sampling was repeated. Depending on the number of closing and reopening actions, enough energy was available for missions of 4 to 8 hours.

Generally, the grab worked almost satisfactorily. In spite of 5 failures during 26 employments with a total time of submergence of more than 80 hours nearly 5 tons of rocks and sediments including 1880 kg of massive sulfides had been recovered.

8.4.5 TV-Grab GTVB

Based on the well-proved electro-hydraulic "Clamshell", this newly designed "Fork Grab" takes requirements into account for the recovery only of hard rock samples without surrounding sediment material. The open construction of the jaws effects the rinsing of soft components during hoisting.

The main dimensions are:

L x W x H (in opened condition)	160 x 275 x 270 cm
L x W x H (in closed condition)	160 x 200 x 350 cm
Weight in air	3.4 t
Weight in water	2.92 t
Base	250 x 160 cm
Capacity	0.9 cm^3
Closing power	35 kN
Operation depth	10,000 m

Apart from some differences in its dimensions the TV-grab GTVB corresponds in all fittings with the GTVA-type.

23 stations have been carried out with the GTVB, recovering nearly 3 t of massive sulfides and rocks during a total time of submergence of more than 100 hours. 11 malfunctions arose including 8 events of energy shortage, due to repeated closing and reopening. The advantage of a better inspection of the clean sample caused in a frequent sampling repetition.

8.4.6 TV-Grab GTVC

Especially with regard to the efficient sampling of massive sulfide deposits this newly constructed electrohydraulic TV-grab "Grappler" had been developed. Based on the good experience with the "Clamshell", technical main parts could be integrated in this grab system (Fig. 8.4.1).

Outstanding features are the 6 grab buckets which cover a sampling area of more than 4 m^2. Lump rock can be crushed by powerful cutting points and a strong closing force ensures reliable grab operation.

The main dimensions are:

Diameter x Height (open condition)	285 x 300 cm
Diameter x Height (closed condition)	185 x 325 cm
Weight in air	3.8 t
Weight in water	3.0 t

Base diameter	250 cm
Capacity	1.0 m^3
Closing power	35 kN
Operation depth	10,000 m

This grab configuration required some technical modifications; nevertheless, optical outfit and handling of the system is similar to both other TV-grabs.

During 54 employments with 15 defects on different reasons 9278 kg massive sulfides and other hydrothermal products as well as 5463 kg basaltic rock material could be recovered. With 200 hours of submergence the TV-grab GTVC was the most successful sampling device.

Photos of the three TV-grabs are presented in the phototables at the end of this report.

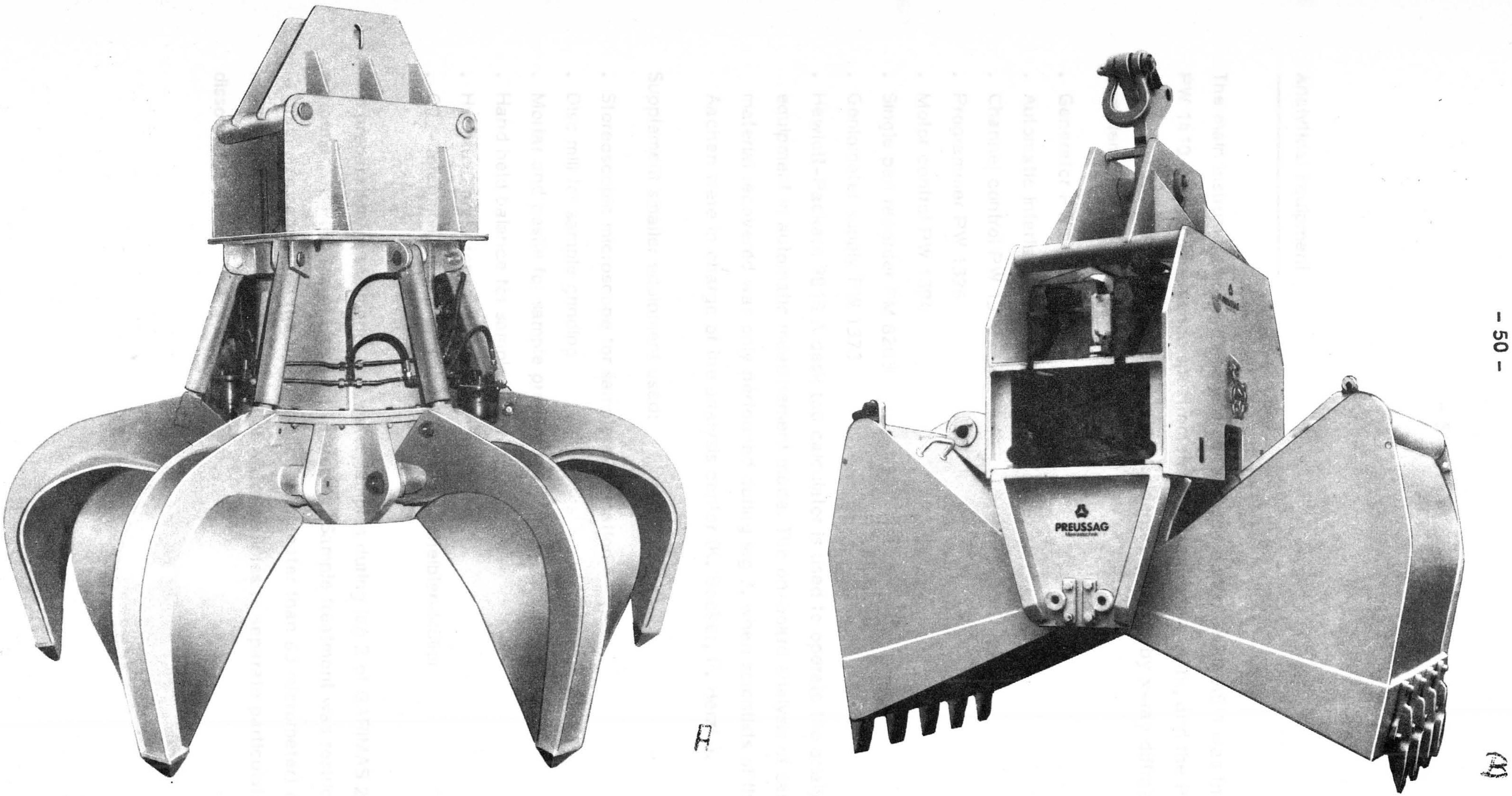


FIG. 8.4.1: THE ELECTRO-HYDRAULIC TV-GRABS "GRAPPLER" (A) AND "CLAMSHELL" (B)

8.5 Analytical Equipment

The main instruments of the analysis center used during GARIMAS 1 was the Philips PW 1410 x-ray fluorescence spectrometer for quantitative work, and the Philips PW 1965/60 proportional detector used to identify minerals by x-ray diffraction. Complementary Philips equipment are:

- Generator PW 1120/90
- Automatic interface PW 1425
- Channel control PW 1390
- Programmer PW 1395
- Motor control PW 1394
- Single pen recorder PM 8203
- Goniometer supply PW 1373
- Hewlett-Packard 9815 A desk top calculator is used to operate the analytical equipment in automatic measurement mode. The on-board analysis of sample material recovered was only performed during leg 3, when scientists of the RWTH Aachen were in charge of the analysis center (K. Becker, P. Herzig).

Supplement smaller equipment used:

- Stereoscopic microscope for sample examination
- Disc mill for sample grinding
- Mortar and pestle for sample preparation
- Hand held balance for sample weighing
- Hydraulic press for sample pelletizing
- CO_2-determination equipment according to Scheibler-Müller

The preparation of sediments and water samples during leg 2 of GARIMAS 2 was performed by P.H. Tse of Hamburg University. Sample treatment was restricted to grain size separation (fractions smaller and greater than 63 micrometer) of sediments by wet filtration and filtration of water samples to separate particulate and dissolved matter.

8.6 Computers

Several computer systems have been used during cruise GARIMAS 2. Many of them belong to specific navigation - and exploration - systems like MAGNAVOX and GPS Satellite navigation, RS/904 navigation, ATNAV navigation and SEABEAM. The latter belong to the standard equipment of the vessel and are not described here.

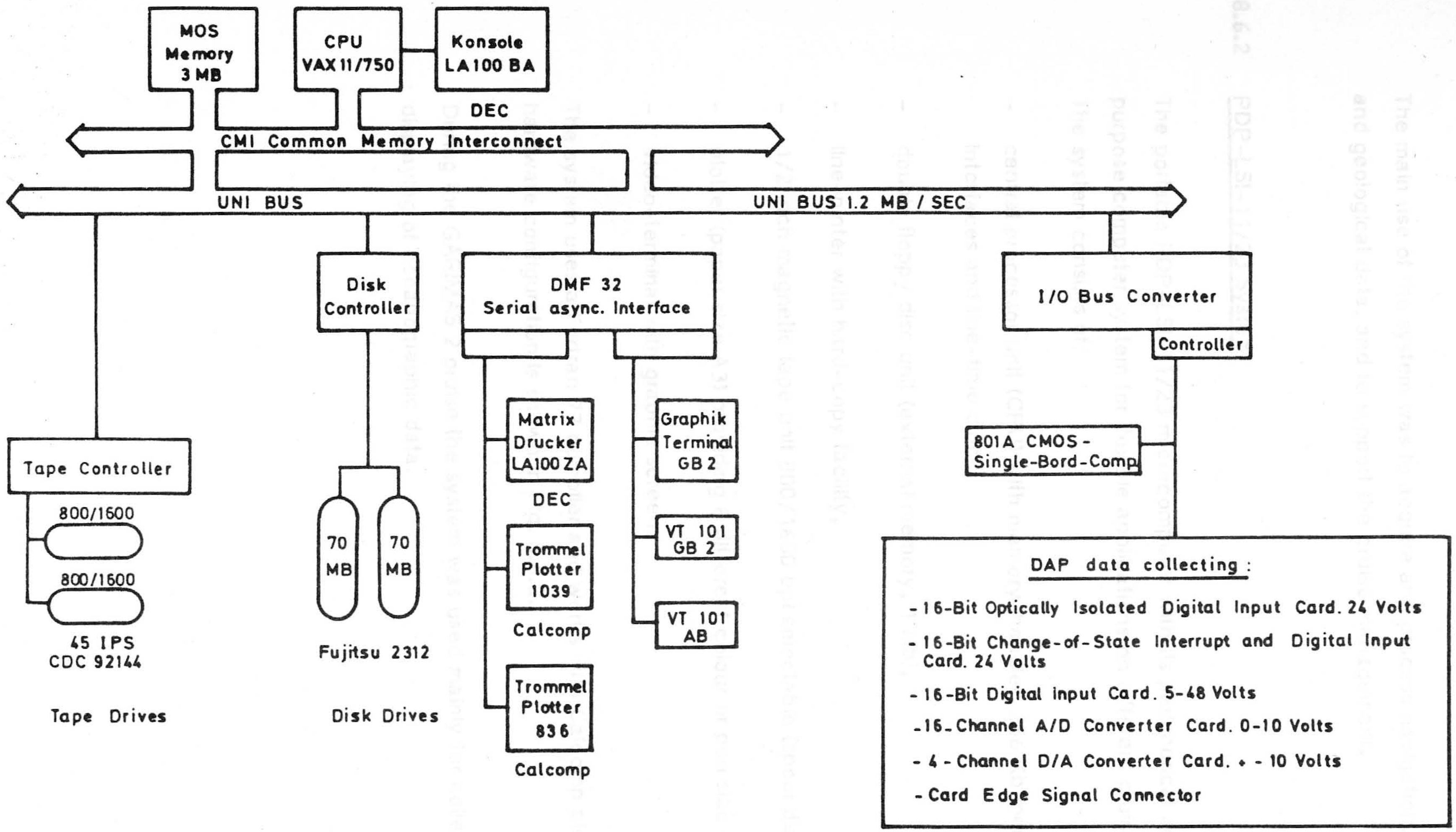
The following two systems were used for real time data acquiring, postprocessing and presentation of navigation and scientific data.

8.6.1 VAX-11/750

The central research Computer-system consists of the following main components (Fig. 8.6.1):

- VAX-11/750 central processor (CPU) with 3 MB Memory,
- dual disc-drive 2 x 70 MB,
- disc-drive 400 MB,
- two tape drives 800/1600 bpi selectable, 45 ips,
- three CRT-graphic terminals,
- CRT-terminal,
- line printer terminal,
- letter printer,
- 3-pen Calcomp plotter,
- data acquisition system: 32 interfaces for parallel and serial transfer.

The system uses a VMS (Vers. 3.5) operation system, and DAP driver software for data acquisition. A Fortran 77 and Macro Assembler Compiler can be used. Several graphic and scientific software libraries are available for the user.



Software producer :

VAX / VMS	V 3.5	11 / 780
FORTRAN	V 3.1	
DAP (Driver für VMS)		
Calcomp (H C B S)		
TDV Minigraph		

FIG. 8.6.1: **The central computer system of FS Sonne**

The main use of the system was to acquire and process navigation, bathymetric and geological data, and to support the cruise management.

8.6.2 PDP-LSI-11/23 System

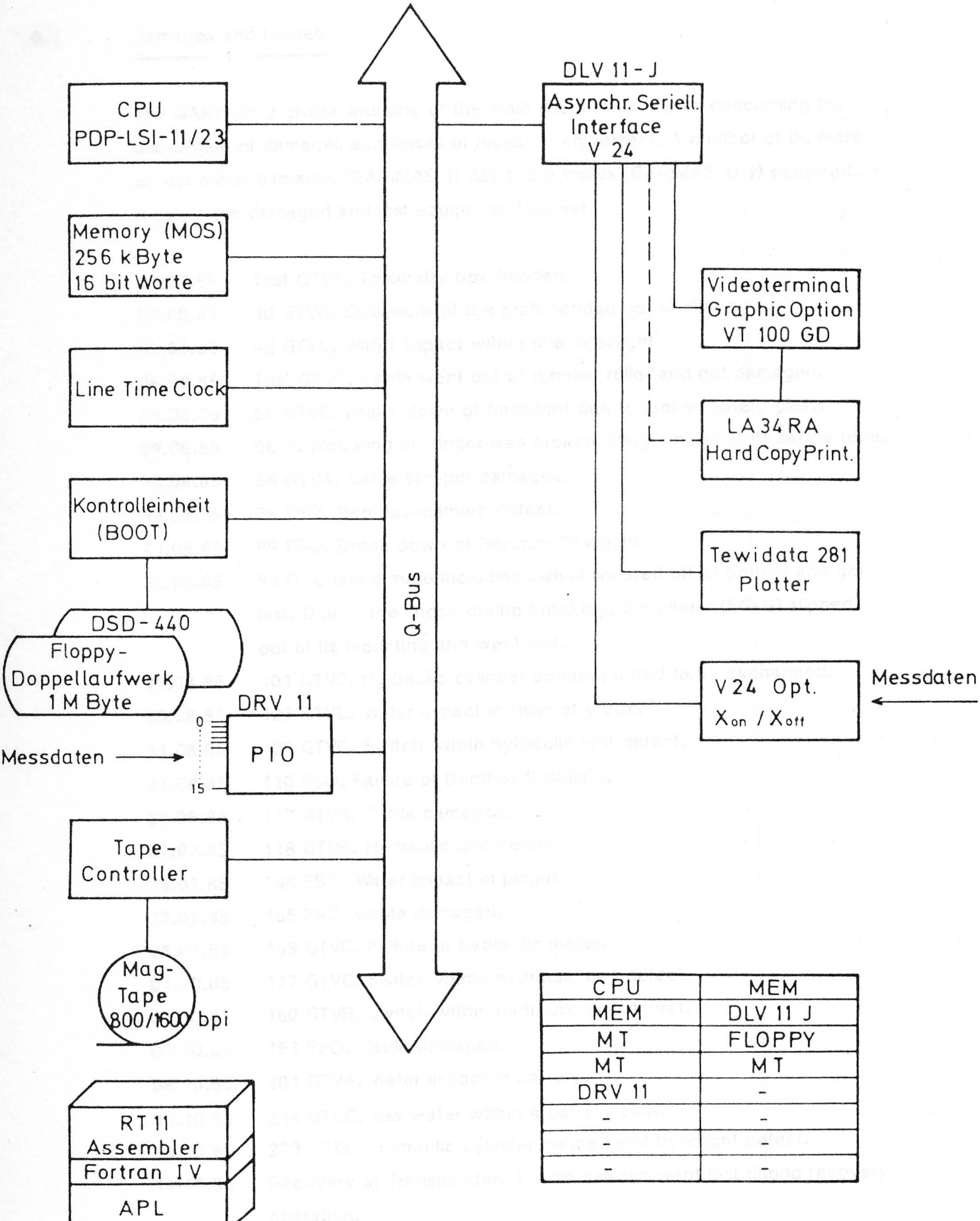
The portable PDP-LSI-11/23 microcomputer with its peripherical devices is a multi-purpose computer system for flexible applications on different cruises and ships. The system consists of:

- central processor unit (CPU) with memory-handler, 256 Kb memory, 4 serial interfaces and line-time clock.
- double floppy disc unit (external memory, 1 Mb),
- line-pinter with hard-copy facility,
- 1/2 inch magnetic tape unit 800/1600 bpi selectable (spool diameter 8 inch),
- plotter (paper size A3) providing 8 different colour or pen size possibilities,
- video-terminal with graphic screen.

The system uses a Fortran 77 compiler and works with Calcomp plot routines. The hardware configuration is shown in Fig. 8.6.2.

During the GARIMAS 2 cruise the system was used mainly for collecting and graphic displaying of oceanographic data.

FIG. 8.6.2: COMPUTER SYSTEM USED FOR THE REGISTRATION AND PROCESSING OF OCEANOGRAPHIC DATA



CPU	MEM
MEM	DLV 11 J
MT	FLOPPY
MT	MT
DRV 11	-
-	-
-	-
-	-

8.7 Damages and Losses

The GARIMAS 2 cruise was one of the most successful cruises concerning the prevention of damages and losses of research equipment. A number of 24 more or less minor damages (GARIMAS 1: 36) and 3 losses (GARIMAS 1: 7) occurred. A list of the damaged and lost equipment follows:

29.07.85	Test GTVB. Telemetry box flooded.
02.08.85	30 GTVB. Side walls of the grab bended out of shape.
05.08.85	42 GTVC. Water impact within one floodlight.
06.08.85	Test GTVC. Cable went out of running roller and got damaged.
08.08.85	56 GTVC. Break down of floodlight due to broken safety glass.
09.08.85	58 D. Mounting of Pinger was broken. Pinger hung at its safety rope.
10.08.85	66 GTVA. Cable stopper damaged.
18.08.85	76 FSO. Benthos-camera defect.
23.08.85	89 FSO. Break down of Benthos flashlight.
25.08.85	93 D. Chain dredge including swivel sheared off at bottom and got lost. Due to the shock during breaking, the pinger (EG+G) slipped out of its mounting and went lost.
29.08.85	101 GTVC. Hydraulic cylinder bended; it had to be exchanged.
30.08.85	103 GTVC. Water impact in telemetry box.
31.08.85	108 GTVC. Switch within hydraulic unit defect.
31.08.85	110 FSO. Failure of Benthos flashlight.
07.09.85	117 GTVB. Cable damaged.
07.09.85	118 GTVB. Hydraulic unit defect.
15.09.85	148 FSO. Water impact in pinger.
27.09.85	165 FSO. Cable damaged.
28.09.85	168 GTVC. Failure of hydraulic motor.
01.10.85	177 GTVC. Switch within hydraulic unit defect.
02.10.85	180 GTVB. Switch within hydraulic unit defect.
05.10.85	193 FSO. Cable damaged.
08.10.85	201 GTVA. Water impact in battery.
11.10.85	216 GTVC. Sea water within 4 battery cells.
13.10.85	223 GTVC. Hydraulic cylinder bended and floodlight defect.
14.10.85	Recovery of Transponder. 1 radio beacon went lost during recovery operation.

9. LOGISTICS, TRANSPORT, SUPPLY AND COMMUNICATIONS

The first leg of the cruise GARIMAS 2 started on July 24, 1985 at Honolulu and ended on July 21, 1985 at Balboa (Panama). Besides the embarkation of one geophysicist and one electronician from Preussag no scientific staff participated in the first leg and no material was loaded in Honolulu.
In Balboa the main refitting of the vessel took place. 310 tons of fuel and 10 tons of oil were taken over. Three 20' containers with scientific equipment were loaded. Two of them (open-top-containers) remained on the ship and one was removed after unloading. Additionally 6 boxes of airfreight were delivered and loaded and one workshop container (10') was taken on board. Besides the loading of fuel and equipment the scientific staff comprising 17 people was embarked in Balboa.
400 litres of battery acid were delivered from the local agent (see below). Before leaving Balboa for the Galapagos working area first analyses revealed that the acid was not good enough for using it in batteries. Within 12 hours new acid with a sufficient quality could be delivered.
The next port call was in Manta (Ecuador) on August 13, where three people disembarked and 5 people embarked. Two of the embarking people were guest scientists from Ecuadorian institutions. During this port call the ship fuelled 150 tons and one 20' container with scientific equipment was loaded.
The third leg ended on September 2 at Manta where again 10 members of the scientific and nautical crew were embarked and disembarked.
During the next port call (17./18.9.) 9 people disembarked and 6 people embarked. Additionally one 20' container with 10 tons of geological samples was unloaded and sent back to Berkhöpen. One empty 20' container and 2 boxes of airfreight were taken on board.
The cruise ended on October 19 at Callao (Peru) where the scientific staff disembarked. In Callao the demobilization took place. Two 20' containers with scientific equipment and samples, one 10' workshop container and three boxes of airfreight were unloaded.
The communication by telex and phone with the company bases in Hannover and Berkhöpen revealed no problems. For the most part communications went via San Francisco Radio.

The agent in Balboa (Panama) was:

Wilford & McKay S.A.

Edificio Portuario

Apartado 782

Balboa/Panama

Telex RCA 8811; phone no. 62-4956

The agent in Manta (Ecuador) was:

Transoceanica CIA Ltd.

P.O.Box 1067

Malecon 1401

Guayaquil/Ecuador

Telex 3371, 3641; phone no. 511360.

The agent in Callao (Lima) was:

Cosmos Agencia Maritima S.A.

P.O. Box 33

Miller 450, Officias 901/903

Callao/Peru

Telex 26039; phone 29 93 67.

10. COOPERATION WITH ATLANTIS II / ALVIN

The presence of R/V ATLANTIS II, carrying the research submarine ALVIN, and of MS SONNE, equipped with heavy duty sampling gear, at the same time near the sulphide sites of the Galapagos Rift provided unique opportunities of scientific-technical cooperation in marine mineral research.

The two vessels operated in the same area of the Galapagos Rift near long. 86°W (for 18 days (Sept. 27 to Oct. 14, 1985).

A II was under contract of NOAA. R.R. Baker was the master of the ship, R.M. Hollis the chief pilot of ALVIN and Dr. R. Embley the chief scientist, assisted by Dr. A. Malahoff, who, during previous ALVIN operations, had located the famous sulphide occurrences of location A.

The other members of the scientific party were: D.B. Foster and W.J. Sellers (pilots); J. Borden, J. Salzig, P.D. Tibbetts, K.J. Mc. Gerge (ALVIN technicians); T. Francis (U.K., I.O.S., resistivity measurements); M. Perfit (Florida Univ., petrology); J. Jonasson (Canad. Geol. Surv., economic geology); St. Jones (NOAA, electronician); R. Avery, A. Silver (Seabeam technicians); A. Arquit, M. Jackson (Univ. Hawaii, grad. stud.); L. Fritz (Rutgers Univ., biologist); M. Tivey, S. Hanneman (grad. students, magnetometry); T. Urabe, M. Yuasa (Japan, geol. survey).

There were also three persons of a television team of the Westgerman Broadcasting Corp. on board ATLANTIS II (Tesche, Thorwarth, Mikelic).

The main goal of the A II / ALVIN operation was the detailed observation of the sulphide bodies of location A within a transponder navigation network. The place had been visited during previous dives (1001, 1002, 1128, 1129) and during Preussag's cruise GARIMAS 1 by MS SONNE. The association of (part of ?) the sulphides with tectonic displacements, leading to mineralized breccias, was of special interest at this location, and the timing of these events could be a major result of the new ALVIN dives. Other important operations of ALVIN at location A were the tests of geophysical methods to locate and to measure sulphide bodies. Electrical resistivity and magnetic measurements were carried out.

From October 8 to 10 three dives (1657 - 1659) were devoted to TV filming at the low-temperature vents of Rose Garden (the film was telecasted by the German television NDR on May 29, 1986). Subsequent dives were carried out at the new hydro-

thermal sites Location C, the silica chimney site (dives 1660, 1663) and B (dive 1661), the main sulphide collection area of SONNE.
During nighttime A II activities comprised Seabeam mapping, mid-water magnetic tows, and dredging, mostly in the location A area and at the intersection of the Galapagos Rift and the Inca Fracture Zone.
Exchange of personnel, information and material during the stay of SONNE and ATLANTIS II in the Galapagos Rift was very extensive and fruitful for both parties. E.g. Seabeam maps from SONNE were used to position ALVIN dives, and eletrical measurements on sulphide samples were used to calibrate in situ measurements. On the other side, the A II biologist went through the SONNE photo series to determine faunal elements, and Dr. Malahoff entered his experiences at location A into the running SONNE operation at this site. Of special interest for the interpretation of the SONNE data and samples was the opportunity of SONNE's chief scientist to dive, together with Dr. Embley, at location B (dive no. 1661, for the track see figs. 10.1 and 10.2). The known specific features of this site and their interrelationship could be studied more closely: young PP lava in the north, an important tectonic line, followed towards the south by a horst structure built up by sheet lavas; associated hydrothermal products (silicates, sulphides); finally the main horst structure in the south, characterized by old PL lava and many faults.

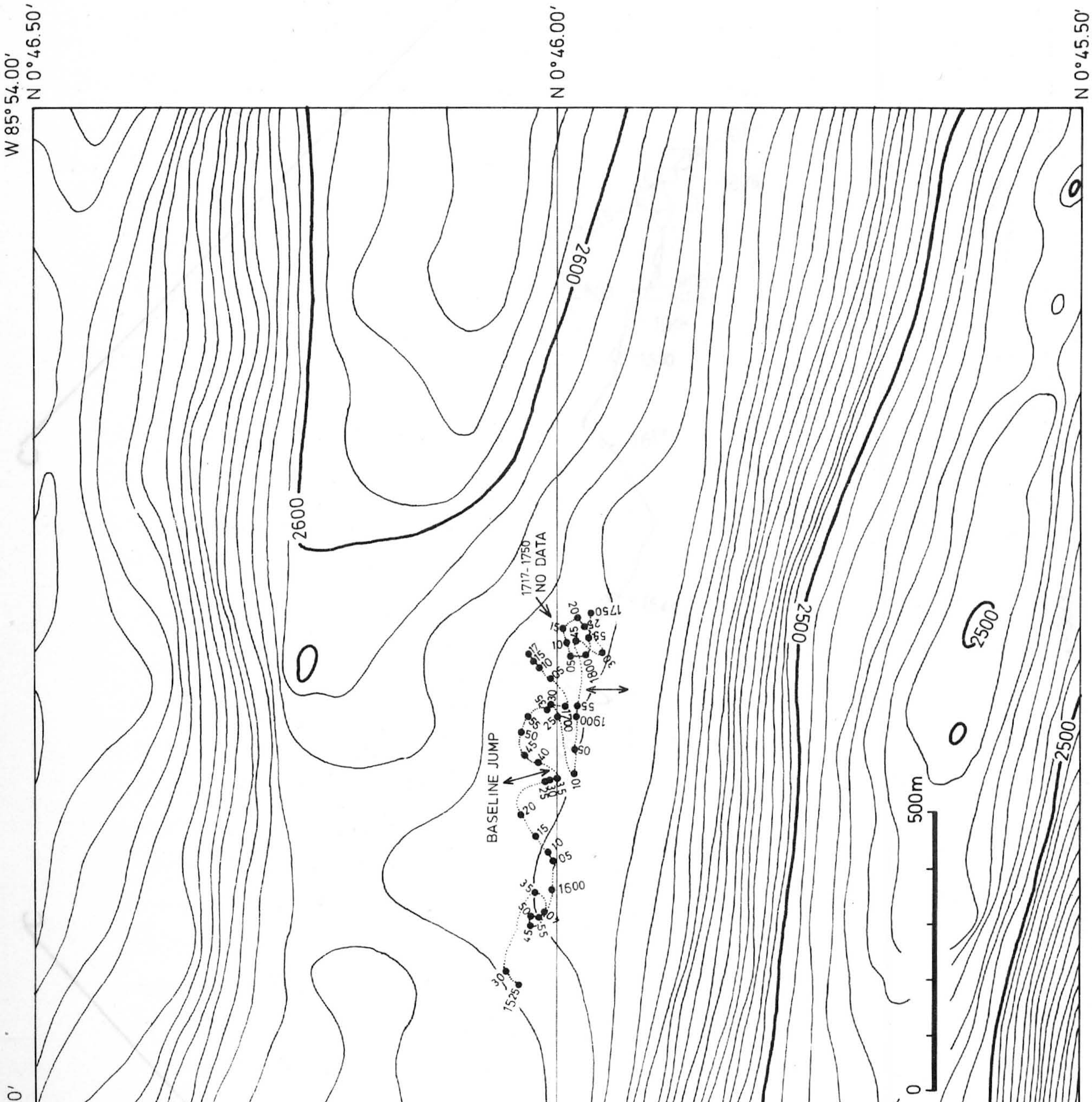


Fig.10.1. DIVE 1661 ALVIN 12.10.1985
Positioning by MS. SONNE (Mo)

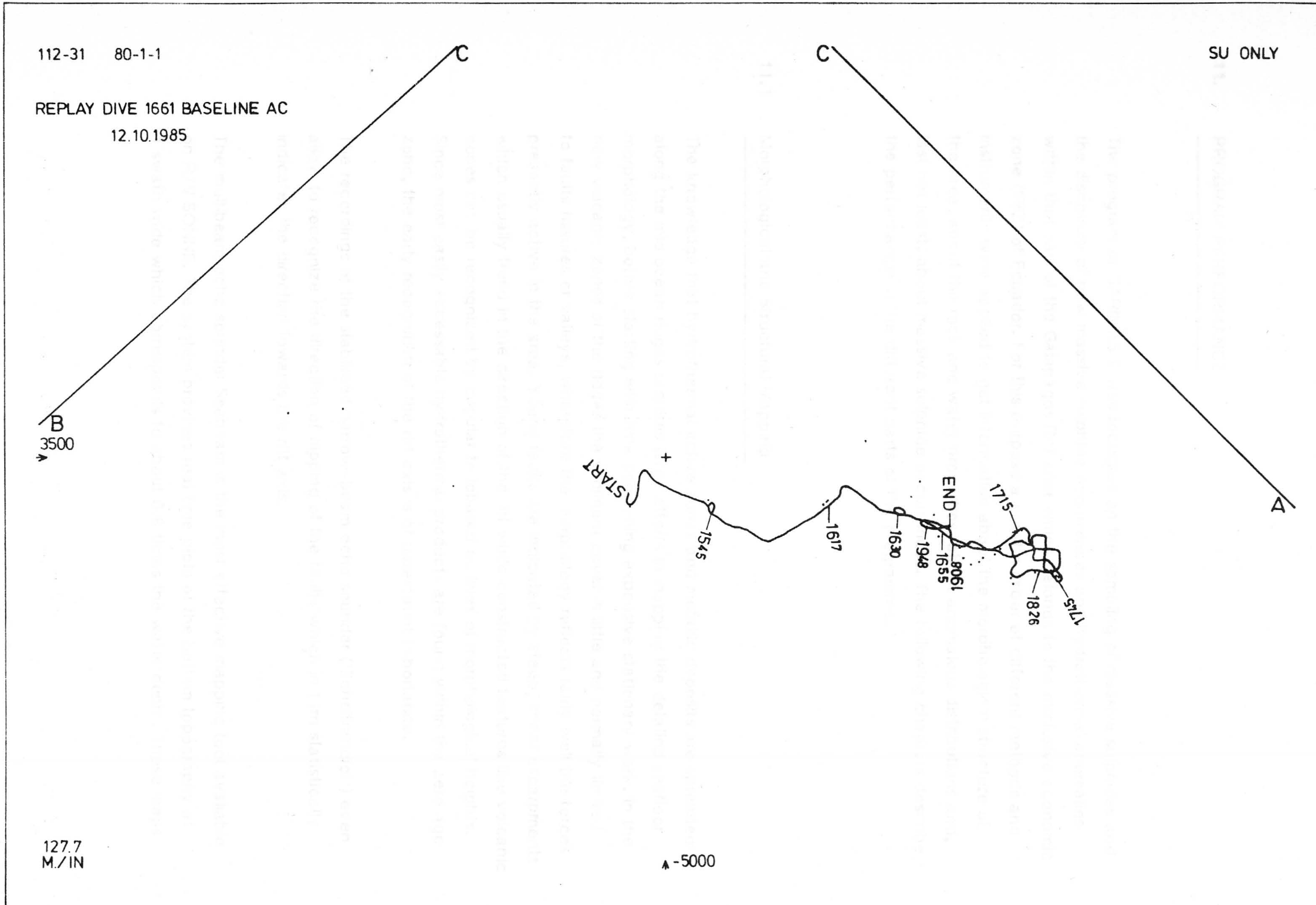

112-31 80-1-1
SU ONLY
REPLAY DIVE 1661 BASELINE AC
12.10.1985
C
C
B
3500
A
START
1545
1617
1630
1948
1655
1908
END
1715
1826
1745
127.7
M./IN
-5000

Fig. 10.2.

11. PROGRAM PERFORMANCE

The program of GARIMAS 2 was focussed on the sampling of massive sulphides and the discovery of new massive sulphide occurrences and hydrothermal anomalies within that part of the Galapagos Rift area which belongs to the exclusive economic zone (EEZ) of Ecuador. For this purpose a great number of different methods and instruments were applied to get information about the morphological structure of the area, about the rock and water properties, about anomalous distributions and, last not least, about massive sulphide occurrences. The following chapters describe the performance of the different parts of the programme.

11.1 Morphological and Structural Mapping

The knowledge that hydrothermal active zones and metallic deposits are spreaded along the mid ocean ridges requires large efforts in mapping the detailed seafloor morphology, before starting with time consuming expensive stationary work. In the new volcanic zones of the ridges the sediment cover is little and normally limited to faults fissures or valleys, wherefore the morphology reflects fairly well the forces presently active in the area. Young faults are indicated by steep, linear escarpments which usually trend in the direction of the rift while constructed features like volcanic cones can be recognized by circular to lobated outlines of morphological heights. Since most easily accessable hydrothermal products are found within the zero age zone, the early recognition of the rift axis is of paramount importance.

The recordings of the stabilized narrow-beam echo sounder ('Schelfrandlot') even allow to recognize the direction of dipping of the faults which in turn statistically indicates the direction towards the rift axis.

The multibeam echo sounder Seabeam is the most effective mapping tool available on R/V SONNE. The system provides real time plots of the bottom topography at a swath wide which corresponds to about 0.8 times the water depth. These maps are supplemented by the recordings of the stabilized narrow beam echo sounder running at 20 or 30 kHz which present a more precise picture of narrow holes or steep slopes.

During cruise GARIMAS 1 the Galapagos Rift has been mapped with Seabeam between 85 W and 96 W. Morphological maps with scales 1:20.000 and 1:50.000 (1:10.000 locations A and B) had been manufactured and were available now for the GARIMAS 2 campaign. During GARIMAS 1, however, (apart from areas A and B) transit navigation had to be used for all Seabeam tracks, wherefore the accuracy of these maps was limited. A total number of 468 supplementary profiles were run during GARIMAS 2 within the survey to extend complete and improve the existing maps. The most of these tracks were based on the Global Positioning GPS navigation.

11.2 Water Sampling and Physical Measurements

The measurements of physical and chemical properties and the sampling of seawater above the Galapagos Rift (GR) were based on mainly two questions:

a) Are there additional hydrothermal anomalies along the GR?, and

b) How are the physical properties and especially the sound velocity within the water column above the GR?

1.6 % of ship time was spent on these investigations.

11.2.1 Water sampling and Sample Preparation

In comparison with normal ocean deep water hydrothermal effluences reveal higher metal concentrations as for example Mn which is up to 10 x 6 times higher. The metal-rich solution is mixed up and diluted by the surrounding deep water. It develops a plume of hydrothermally influenced water which shows besides the well to distinguish metal-anomalies in some cases anomalies of temperature, light attenuation or sound velocity. Whereas the latter could be determined directly in situ with the probes of the Multisonde the metal contents had to be determined at water samples within the ship's and home laboratories.

With the aim to sample and measure hydrothermal plumes a number of 168 water samples were taken on 14 locations (see Fig. 11.2.1). The distance between the different sample positions was about 2 nautical miles extending along the GR between 85°42' and 86°17' W. One set of samples was taken within a probably active area at 95°05' W.

The sampling was carried out with a rosette sampler which was equipped with 12 non-metallic 5 l Niskin bottles. The sampling depth was 20, 40, 60, 80, 100, 120, 140, 160, 200, 250, 300 and 400 meters above the seafloor. The sampling depth was determined with the pressure probe and the bottom toucher of the Multisonde. Directly after sampling the water samples partly were filtered and fixed (see Tab. 11.2.1).

TAB. 11.2.1 SAMPLE PREPARATION

SAMPLE		REMARKS
UNFILTERED	FILTERED	
250 ml fixed with HCl 350 ml	500 ml fixed with HCl 700 ml	determination of the entire particulate Mn-contents
50 ml fixed with $HgCl_2$ 500 µl	100 ml fixed with $HgCl_2$ 1000 µl	determination of the entire dissolved and undissolved organic matter and nutrients

11.2.2 Multisonde Measurements

During GARIMAS 2 the STD-measurements carried out with the multi-sensing probe Multisonde mainly should help to discover hydrothermal anomalies along the GR and to gather information about them. This interest focussed the attention on the deep water body some 400 m above the seafloor. Some supplementary measurements were carried out to provide temperature, salinity and sound velocity profiles over the entire water column for the calibration of the Seabeam system. Altogether a number of 15 STD-profiles were measured (Tab. 11.2.2). They were preprocessed, plotted and controlled directly after measurement.

In ANNEX 2 hard-copies of the bottom-near section of the on-line plots are presented.

From these profiles the temperature and light transmission data were of special interest, when searching for hydrothermal anomalies. For this reason a special attention was attached to these data. Nevertheless the pre-evaluation performed on board did not reveal any anomaly of deep water properties.

Finally it should be mentioned that the multi-sensing system revealed only small misfunctions and worked nearly without any downtime.

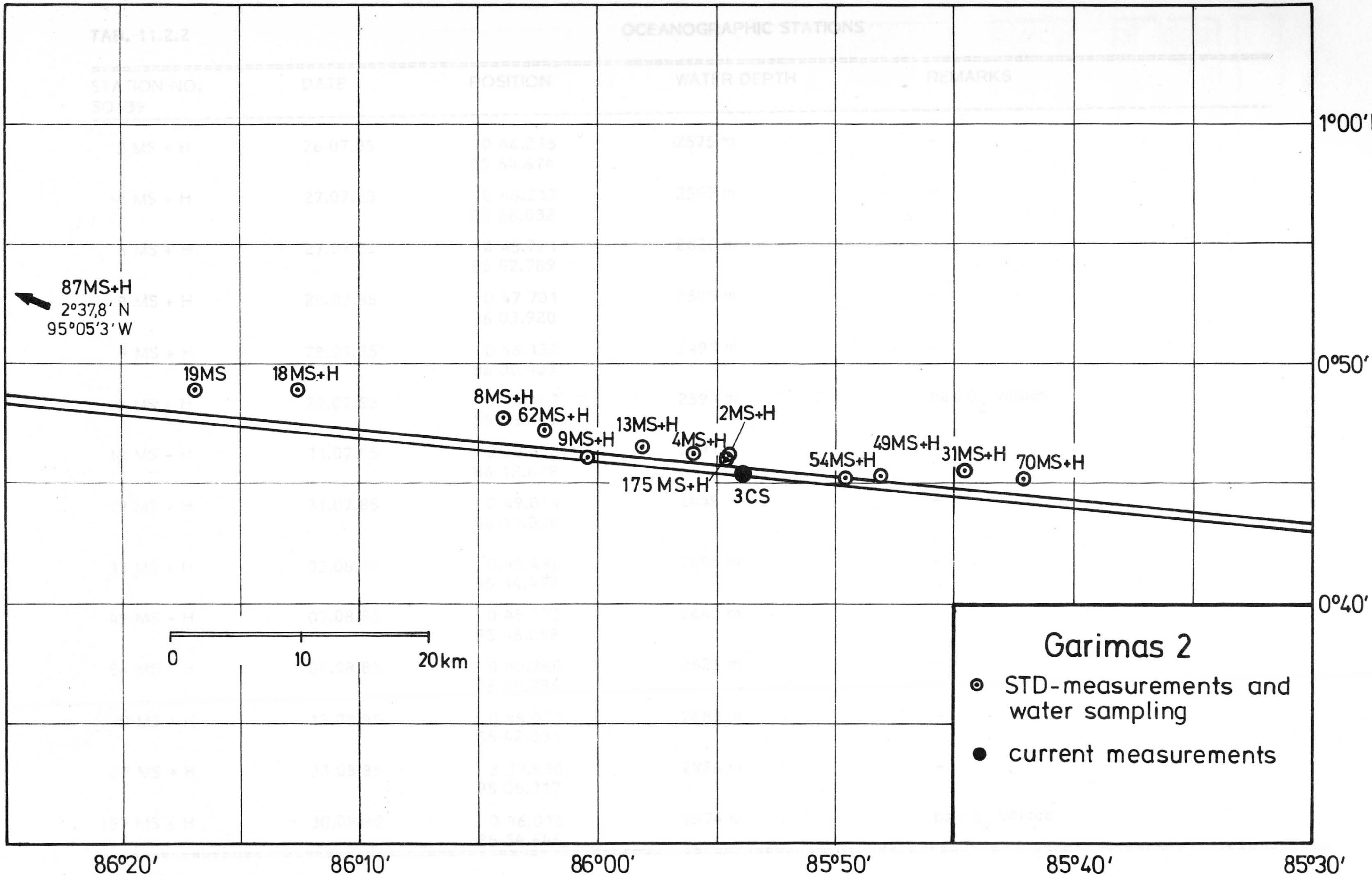
11.2.3 Current Measurements

Information about current velocity and direction above the GR gathered during former cruises show that there is a high variability in the current pattern of that area. Therefore the necessity of supplementary current measurements was obvious. One current meter was moored together with a transponder of the underwater navigation array at about the same position like the former current meter stations (see Fig. 11.2.1). The instrument was suspended for a period of 81 days. All station data are collected and presented within the station record (Tab. 11.2.3).

A short pre-processing of the current meter data demonstrated that the instrument worked without failures.

Selected data gathered from Multisonde and current meter measurements are presented within Chapter 11.8 of this report.

FIG. 11.2.1 OCEANOGRAPHIC STATIONS ALONG THE GALAPAGOS RIFT CREST



TAB. 11.2.2 OCEANOGRAPHIC STATIONS

STATION NO. SO-39	DATE	POSITION	WATER DEPTH	REMARKS
2 MS + H	26.07.85	0 46.215 85 54.674	2575 m	–
4 MS + H	27.07.85	0 46.212 85 56.032	2559 m	–
5 MS + H	27.07.85	0 45.721 85 52.789	2626 m	–
8 MS + H	28.07.85	0 47.701 86 03.920	2505 m	–
9 MS + H	28.07.85	0 46.132 86 00.403	2493 m	–
13 MS + H	29.07.85	0 46.467 85 58.169	2590 m	bad 0_2 values
18 MS + H	31.07.85	0 48.858 86 12.628	2491 m	–
19 MS + H	31.07.85	0 49.014 86 17.036	2448 m	–
31 MS + H	03.08.85	0.45.496 85 44.477	2685 m	–
49 MS + H	07.08.85	0 45.173 85 48.058	2642 m	–
54 MS + H	08.08.85	0 45.260 85 49.786	2626 m	–
70 MS + H	12.08.85	0 45.073 85 42.031	2689 m	–
87 MS + H	23.08.85	2 37.810 95 05.317	2986 m	–
157 MS + H	30.09.85	0 46.016 85 54.646	2574 m	bad 0_2 values

TAB. 11.2.3:

RECORD CURRENT MEASUREMENTS

RESEARCH VESSEL:	SONNE
CRUISE:	GARIMAS 2
SEA AREA:	Galapagos Rift 85 deg. area
PROTOCOL:	J. Post

STATION No.: SO 39 - 03 CS

CURRENT METER MOORING	+
CURRENT METER PROFILER	-
SURFACE DRIFT BUOY	-
UNDERWATER DRIFT FLOAT	-

		SUSPENDING	RECOVERING	1. POSITION CHECK	2. POSITION CHECK
DATE:		26.07.85			
START OF OPERATION		13.50			
REACHING OP. DEPTH		14.42			
END OF OPERATION		14.25			
POSITION	LAT. N	0°45.53 '	° '	° '	° '
	LONG. W	85°53.82 '	° '	° '	° '
WATER DEPTH		(m)	(m)	(m)	(m)
ECHO SOUNDER (UNCORR.)		-			
MATTHEWS CORRECTED		2520			
BRINE CORRECTED		-			
WIND SPEED	kn	8			
WIND DIRECTION	%	240			
SEA STATE	m	1.0			
SWELL	m	1.0			
CLOUDINESS	x/8	8			

CURRENT METER		1	2	3	4	5	6	7	8
INSTRUMENT No.		6742							
REC. START	DATE	26.7.85							
	TIME	12.20							
REC. END	DATE	14.10.85							
	TIME	21.15							
OPERATION DEPTH		2410							

REMARKS:
- 20 minutes recording interval
- all times in GMT

11.3 Visual Seafloor Investigations

The visual mapping of seafloor structures was one of the main tasks of GARIMAS 2. 29 % of the total available ship time were devoted to the visual observation by TV- or photographic systems. Two systems were employed:

- The OFOS sledge, equipped with television cameras (black/white and colour) and photo cameras for 24 x 36 mm film
- Three types of grab-systems, equipped with black and white TV-cameras.

While the OFOS-sledge (Ocean Floor Observation System) exclusively served to map the bottom structures, the grab-system was mainly used to sample hydrothermal features and the TV-record was obtained as a by-product.

The OFOS seafloor mapping was performed for three different tasks:

- to verify the o-age axis of the spreading center in unknown areas by determination of the sediment cover and appearance (freshness) of lava flows
- to verify volcanic and tectonic elements of the spreading axis, previously recognized resp. deduced from bathymetric maps
- to localize places with hydrothermal activity and products and map the size of these areas.

In total 62 OFOS-stations were placed, resulting in 30 426 colour slides of the seafloor.

The total time of TV-Video-records obtained by OFOS amounts to 202 h, the TV-records of the grab-systems (GTVA, GTVB, GTVC) sum up to 221 h. The total TV-record time amounts to 18 days.

Usually locations for visual OFOS-profiles were chosen on the basis of bathymetric maps or at least a Seabeam swath. Generally the combination of TV and photography was applied. The seafloor and the distance to the seafloor were observed continuously by TV, and the camera was released manually. Thus overlapping photos could be shot at important sites, and recording rates could be reduced in uniform environments.

Good pictures were obtained at bottom distances between 3 and 10 metres.
Off bottom the position of the sledge was controlled by pinger signals which determined the distance to the ocean floor (Fig. 11.3.2). Typical photo profiles were about 0.5 to 2 nautical miles long. The geographic position of the sledge with respect to the ship's position was either determined by a RS 904 ultra-short base line system during GPS- or SATNAV-navigation or by an EGG-subtransponder within ATNAV-arrays (Location B). The sledge positions of all stations were immediately processed on board and plotted by the VAX/CALCOMP-system.
During TV-seafloor observation the features observed were on-line stored in the VAX-computer and correlated with time, cable length and water depth (GEO-program). After termination of the station or after completing one 30 m film, the latter was developed immediately on board. All photos produced during GARIMAS 2 are slides. The slides were described on board.
While the interpretation of the black and white TV records is difficult and ambiguous, the photos clearly show the nature of the seafloor. In a data field on each photo the following information is presented: first row: hours, minutes; second row: seconds, days; third row: bottom distance in metres up to 9,9 m maximum. The results of photographic stations occupied during cruise SO 39 are summarized in Table 11.3.1.
An example of a bottom-photo is presented within the photo tables attached at the end of this report.
Outside the photo stations, TV observation was mainly used to select sample points. For this purpose the different types of TV-grabs (GTVA, GTVB, GTVC) were slowly moved over prospective areas. Outside the neo-volcanic zone of the rift this operation was rendered difficult by sediment turbidity in the water caused by the up and down movement of the instruments. In the main working area (Locations A and B) objects to recover are partly buried by unconsolidated sediments. Discrimination between sulfides, breccias and certain types of ponded lava requires much experience.
The total number of TV profiles obtained during GARIMAS 2 was 166 (OFOS + TV-grab), 62 of which were combined with photographing (OFOS).
Ship's speed during OFOS-stations was adjusted to 0.5 to 1 kn (= 0.25 - 0.5 m/sec) in order to avoid risks of damage or loss in dangerous areas (scarps, faults, fissures).
A set of tables and figures is attached presenting the following information:

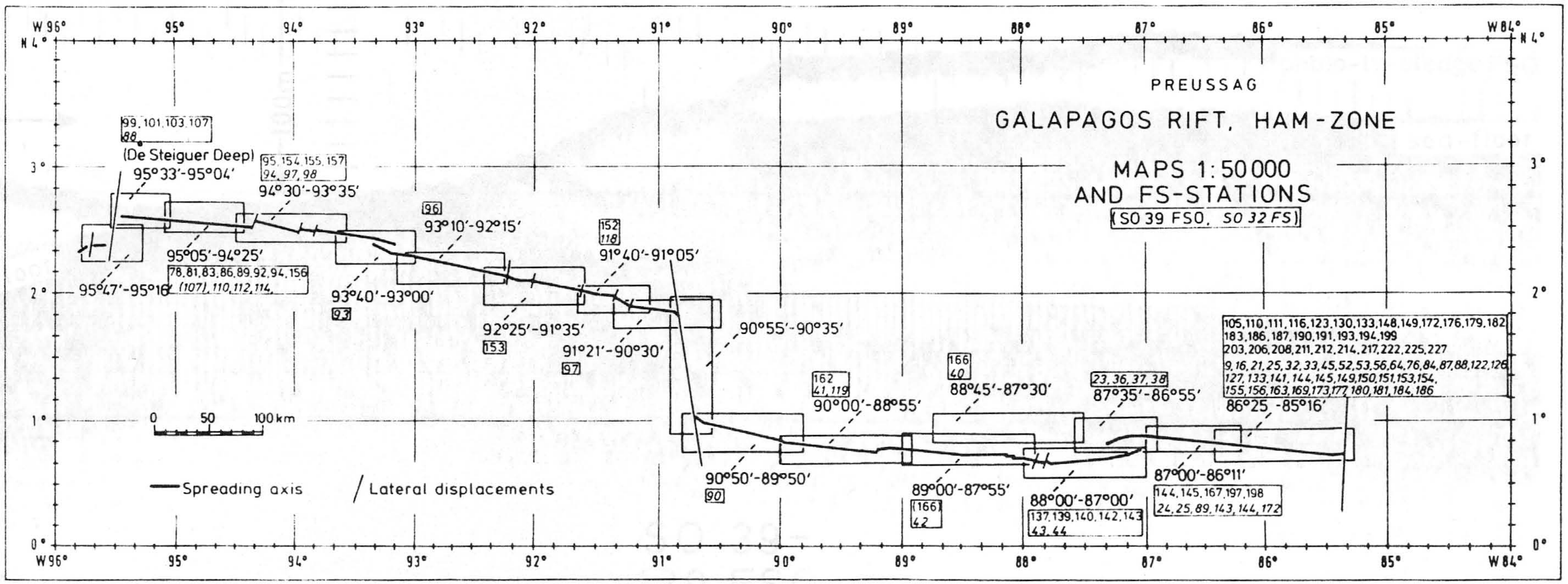


FIG. 11.3.1: REGIONAL DISTRIBUTION OF FS-(OFOS)-STATIONS

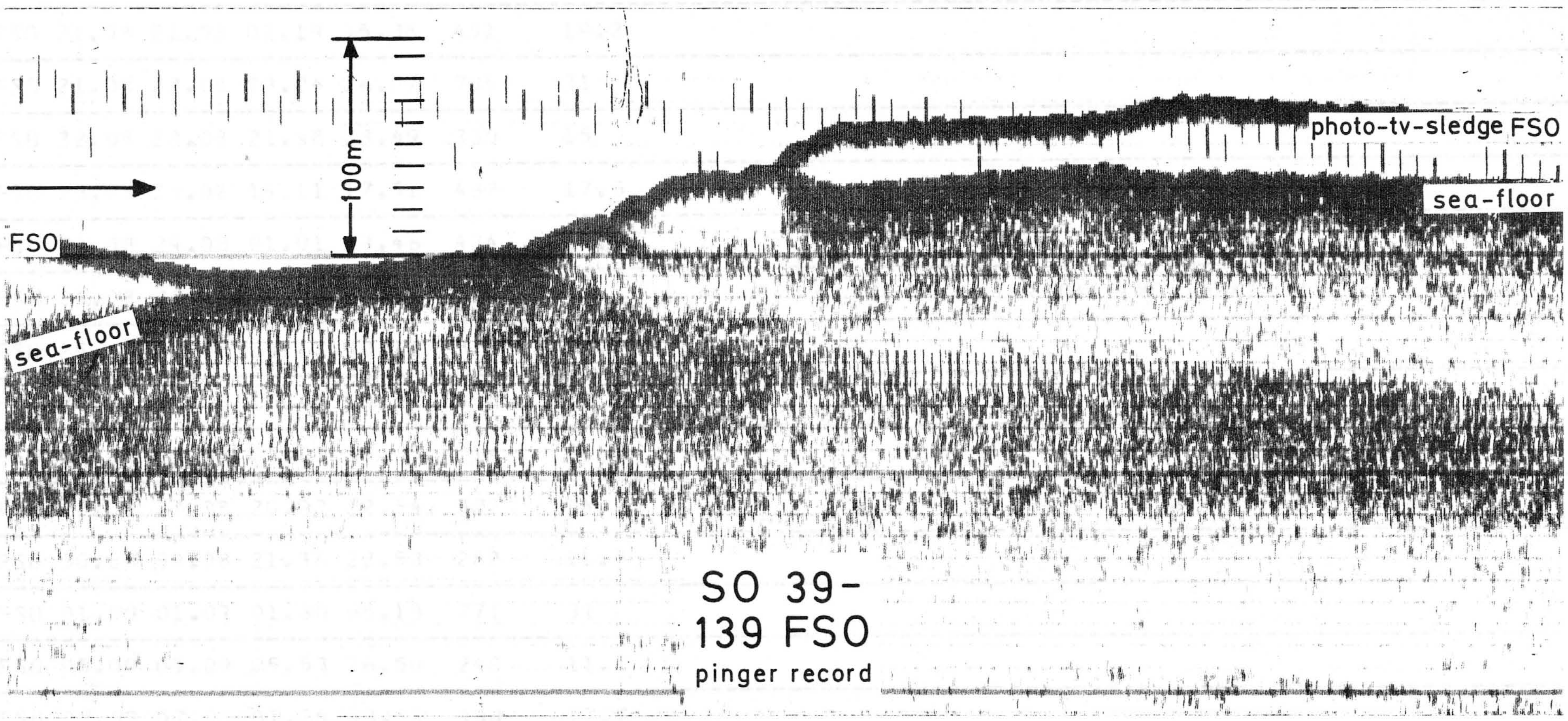


FIG. 11.3.2: CONTROL OF OFOS-SEAFLOOR DISTANCE BY 16 KHZ PINGER RECORD

TAB. 11.3.1: LIST OF PHOTO PROFILES (GARIMAS 2 - SO 39)

STATION	DATE FROM	DATE TO	AT BOTTOM FROM	AT BOTTOM TO	NO.OF PHOTOS	FILM-LENGTH	CO-PIED	FRAM-ED	REMARKS
76-FSO	19.08	19.08	03.40	05.09	76	6.8			TEST
78-FSO	20.08	20.08	03.03	05.44	246	11.3			
81-FSO	21.08	21.08	02.19	05.38	451	19.2			
83-FSO	21.08	22.08	23.24	06.07	755	31			
86-FSO	22.08	22.08	21.48	23.49	330	15			
88-FSO	23.08	23.08	14.11	17.51	432	17.5			
89-FSO	24.08	24.08	01.01	03.46	424	18.8			
92-FSO	24.08	24.08	19.08	22.42	633	27			TURBID WATER (ACTIVE SMOKER ?)
94-FSO	25.08	26.08	23.17	03.17	573	24.7			
95-FSO	26.08	26.08	15.45	19.05	475	19.7			
96-FSO	27.08	27.08	03.01	04.35	214	9.5			
97-FSO	27.08	27.08	20.32	22.54	322	14.2			
105-FSO	30.08	30.08	21.36	22.53	282	11.8			
110-FSO	01.09	01.09	01.30	05.13	771	31			
111-FSO	05.09	05.09	05.53	06.50	240	11.1			
116-FSO	07.09	07.09	01.35	03.58	430	17.7			
123-FSO	08.09	08.09	15.25	19.08	686	30.5			
130-FSO	09.09	09.09	19.12	23.01	704	30.5			
133-FSO	10.09	10.09	16.26	22.11	762	30.5			

TAB. 11.3.1: LIST OF PHOTO PROFILES (GARIMAS 2 - SO 39)

STATION	DATE FROM	DATE TO	AT BOTTOM FROM	AT BOTTOM TO	NO.OF PHOTOS	FILM-LENGTH	CO-PIED	FRAM-ED	REMARKS
137-FSO	12.09	12.09	02.34	05.22	456	19.6			
139-FSO	12.09	12.09	19.46	21.31	179	8.5			
140-FSO	13.09	13.09	02.33	05.45	566	22.8			
142-FSO	13.09	13.09	18.10	20.04	139	7.40			
143-FSO	14.09	14.09	00.45	02.20	253	10.6			
144-FSO	14.09	14.09	16.20	18.39	320	13.9			
145-FSO	15.09	15.09	00.17	03.57	770	30.5			
148-FSO	15.09	15.09	18.40	21.55	774	30.5			
149-FSO	16.09	16.09	00.56	03.01	432	18.3			
152-FSO	21.09	21.09	19.20	21.41	401	18.0			
153-FSO	22.09	22.09	02.32	06.01	716	30.5			
154-FSO	22.09	22.09	17.45	22.37	768	30.5			
155-FSO	23.09	23.09	03.23	06.13	610	25.4			
156-FSO	23.09	24.09	18.10	03.53	741	30.5			
157-FSO	24.09	25.09	16.45	00.37	744	30.5			
162-FSO	27.09	27.09	00.16	03.59	710	30.5			
165-FSO	27.09	27.09	18.51	20.53	320	14.7			
166-FSO	28.09	28.09	01.11	02.18	194	7.9			
167-FSO	28.09	28.09	13.33	15.22	328	14.5			

TAB. 11.3.1: LIST OF PHOTO PROFILES (GARIMAS 2 - SO 39)

STATION	DATE FROM	DATE TO	AT BOTTOM FROM	AT BOTTOM TO	NO. OF PHOTOS	FILM-LENGTH	COPIED	FRAMED	REMARKS
172-FSO	30.09	30.09	01.22	04.00	374	15.5			
176-FSO	01.10	01.10	01.12	03.57	737	30.5			WRONG DATE: 31.SEP. , CORRECT: 1. OCT.
179-FSO	02.10	02.10	-	-	0	-			FILM NOT TRANSPORTED
182-FSO	02.10	02.10	19.00	19.47	270	10.8			LIGHT LEAK UNTIL 19.00 (DEVELOPING BATH)
183-FSO	03.10	03.10	00.07	03.36	684	28.2			
186-FSO	03.10	03.10	19.06	23.30	746	30.5			
187-FSO	04.10	04.10	03.43	06.10	724	30.5			
190-FSO	04.10	04.10	19.35	22.23	733	30.5			
191-FSO	05.10	05.10	01.51	04.17	724	30.5			
193-FSO	05.10	05.10	18.22	22.47	670	27.8			
194-FSO	06.10	06.10	01.26	03.20	503	21.1			
197-FSO	06.10	06.10	21.13	23.40	537	25.8			FROM 23.26 PHOTOS BLACK (82 PHOTOS UNEXPOSED)
198-FSO	07.10	07.10	02.21	05.17	675	28.0			
199-FSO	07.10	07.10	14.59	16.48	169	8.0			
206-FSO	09.10	09.10	09.05	10.50	431	18.1			
208-FSO	09.10	09.10	18.39	21.37	752	30.5			
211-FSO	10.10	10.10	08.30	09.40	277	12.0			
212-FSO	10.10	10.10	10.47	12.20	474	18.0			
214-FSO	11.10	11.10	02.02	04.40	757	30.5			

TAB. 11.3.1: LIST OF PHOTO PROFILES (GARIMAS 2 - SO 39)

STATION	DATE FROM	DATE TO	AT BOTTOM FROM	AT BOTTOM TO	NO. OF PHOTOS	FILM-LENGTH	CO-PIED	FRAM-ED	REMARKS
217-FSO	11.10	12.10	21.52	00.16	732	30.5			
222-FSO	12.10	13.10	22.38	02.47	421	18.2			
225-FSO	13.10	13.10	16.57	20.29	749	30.0			
227-FSO	14.10	14.10	05.56	06.06	50	3.0			

TAB. 11.3.2: LIST OF TV-PROFILES (GARIMAS 2 - SO 39)

STATION	DATE FROM	DATE TO	TAPE ON	TAPE OFF	AT BOTTOM FROM	AT BOTTOM TO	REMARKS
001-GTVC							TEST OF GRAB
006-GTVC	27.07	27.07	16.42	19.53	16.43	19.46	TOF1: 19.36 , TON2: 19.37
007-GTVC	27.07	28.07	23.06	00.50	23.08	00.47	
011-GTVC	29.07	29.07	02.18	04.25	02.19	04.20	
012-GTVC	29.07	29.07	10.25	11.48	10.26	10.40	
016-GTVC	30.07	30.07	18.03	19.16	18.03	19.11	
017-GTVC	31.07	31.07	00.42	06.53	00.44	06.51	TOF1: 03.46 , TON2: 03.47
020-GTVC	01.08	01.08	02.03	02.23	02.05	02.19	
021-GTVC	01.08	01.08	03.56	04.04	03.59	04.01	
025-GTVB	02.08	02.08	01.13	02.54	01.15	02.48	
027-GTVA	02.08	02.08	10.50	12.37	10.50	12.37	12.37 DISCONNECTION OF DATA TRANSFER
030-GTVB	03.08	03.08	04.36	09.08	04.37	09.03	TOF1: 08.27 , TON2: 08.28
033-GTVB	03.08	04.08	23.33	00.32	23.35	00.21	NO RECORDING: 00.26 TO 00.31
034-GTVB	04.08	04.08	02.56	03.40	02.58	03.36	
035-GTVA	04.08	04.08	09.59	10.39	10.04	10.30	
036-GTVA	04.08	04.08	13.51	14.33	13.52	14.28	
037-GTVA	04.08	04.08	17.02	18.26	17.03	18.15	
038-GTVC	04.08	04.08	21.55	22.21	21.56	22.16	
039-GTVC	05.08	05.08	02.44	02.57	02.46	02.50	

TAB. 11.3.2: LIST OF TV-PROFILES (GARIMAS 2 - SO 39)

STATION	DATE FROM	DATE TO	TAPE ON	TAPE OFF	AT BOTTOM FROM	AT BOTTOM TO	REMARKS
040-GTVC	05.08	05.08	06.32	08.41	06.33	08.32	
041-GTVC	05.08	05.08	11.44	13.13	11.47	13.06	
042-GTVC	05.08	05.08	16.39	18.27	16.39	18.08	TOF1:17.23 , TON2:17.59 , NO RECORD: 18.15 TO 18.22
043-GTVB	06.08	06.08	00.26	04.03	00.29	03.54	TOF1:03.10 , TON2: 03.11
047-GTVC	07.08	07.08	01.59	03.19	02.04	03.14	
050-GTVC	07.08	07.08	12.59	13.05	13.01	13.04	
051-GTVA	07.08	07.08	17.09	17.27	17.10	17.22	
052-GTVC	07.08	07.08	21.30	23.55	21.33	23.53	NO RECORD:21.46 TO 23.39
053-GTVC	08.08	08.08	03.17	06.11	03.20	06.05	TOF1:05.34 , TON2:05.36
055-GTVC	08.08	08.08	14.39	14.48	14.41	14.44	
056-GTVC	08.08	08.08	17.40	19.56	17.41	19.55	
057-GTVC	09.08	09.08	02.06	04.42	02.10	04.40	
060-GTVC	09.08	09.08	16.36	17.45	16.38	17.41	
061-GTVC	09.08	09.08	21.43	23.10	21.47	23.06	
063-GTVC	10.08	10.08	11.16	11.43	11.18	11.41	
064-GTVC	10.08	10.08	14.52	16.20	14.54	16.19	CAMERA BLACK OUT:16.19
065-GTVC	10.08	10.08	20.54	21.57	20.55	21.50	
066-GTVA	11.08	11.08	07.10	09.28	07.12	09.28	NO RECORD:07.37 TO 08.01
068-GTVA	11.08	11.08	16.49	18.44	16.49	18.38	

TAB. 11.3.2: LIST OF TV-PROFILES (GARIMAS 2 - SO 39)

STATION	DATE FROM	DATE TO	TAPE ON	TAPE OFF	AT BOTTOM FROM	AT BOTTOM TO	REMARKS
076-FSO	19.08	19.08	03.40	05.09	03.44	05.08	
078-FSO	20.08	20.08	03.01	05.45	03.03	05.44	RCON/OFF: 04.20 - 04.37
081-FSO	21.08	21.08	02.19	05.39	02.24	05.38	RCON/OFF:02.36 - 02.42 , 04.40 - 04.44
083-FSO	21.08	22.08	23.19	06.08	23.24	06.07	RCON/OF:2.43-3.20,3.57-4.46,TOF1:2.24,TON/OF2:2.26-5.31,TON3:5.34
086-FSO	22.08	22.08	21.45	23.50	21.48	23.49	
088-FSO	23.08	23.08	14.13	18.06	14.13	18.04	RCON/OF:14.19-14.35 , 18.00-18.04 , TOF1:17.16 , TON2:17.17
089-FSO	24.08	24.08	00.58	03.46	01.01	03.46	RCON/OFF:01.37-02.24 , 03.39-03.46
092-FSO	24.08	24.08	19.05	22.45	19.08	22.43	RCON/OFF:19.10-19.19 , 20.23-20.26 , TOF1:22.10 , TON2:22.11
094-FSO	25.08	26.08	23.16	03.20	23.19	03.18	RCON/OFF:01.53-02.00 , 03.02-03.19 , TOF1:02.12 , TON2:02.13
095-FSO	26.08	26.08	15.42	19.09	15.45	19.05	TOF1:18.47 , TON2:18.52
096-FSO	27.08	27.08	03.00	04.37	03.01	04.36	RCON/OFF:03.19-03.26
097-FSO	27.08	27.08	20.36	22.54	20.38	22.54	RCON/OFF:20.58-21.09
101-GTVC	29.08	29.08	19.48	20.00	19.50	19.54	ADDITIONAL RECORD FROM 20.02 TO 20.08
102-GTVB	29.08	30.08	23.25	03.39	23.26	03.36	TOF1:02.17 , TON2:02.18
103-GTVC	30.08	30.08	08.06	08.17	08.06	08.14	
104-GTVB	30.08	30.08	16.37	18.15	16.39	18.12	
105-FSO	30.08	30.08	21.34	22.54	21.36	22.54	RCON/OFF:22.09-22.34
106-GTVB	31.08	31.08	02.26	04.27	02.28	04.21	
107-GTVB	31.08	31.08	08.30	09.58	08.34	09.55	

TAB. 11.3.2: LIST OF TV-PROFILES (GARIMAS 2 - SO 39)

STATION	DATE FROM	DATE TO	TAPE ON	TAPE OFF	AT BOTTOM FROM	AT BOTTOM TO	REMARKS
108-GTVC	31.08	31.08	14.59	16.32	15.00	16.29	
109-GTVB	31.08	31.08	20.29	21.53	20.30	21.50	
110-FSO	01.09	01.09	01.28	05.20	01.30	05.19	RCON/OF:02.33-02.45,02.48-03.12,03.59-05.19,TOF1:04.33,TON2:04.34
111-FSO	05.09	05.09	05.50	06.50	05.53	06.50	RCON/OFF:06.16-06.50
112-GTVB	05.09	05.09	14.24	14.41	14.26	14.37	
113-GTVB	05.09	05.09	16.37	18.18	16.39	18.17	
114-GTVB	06.09	06.09	04.39	09.20	04.41	09.15	TOF1:07.43 , TON2:07.45
115-GTVB	06.09	06.09	12.05	16.53	12.09	16.52	TOF1:15.56 , TON2:15.56
116-FSO	07.09	07.09	01.33	03.59	01.35	03.59	RCON/OFF:01.40-01.43 , 02.30-02.34 , 02.45-03.13
117-GTVB	07.09	07.09	14.28	15.31	14.30	15.28	
118-GTVB	07.09	07.09	20.48	21.40	20.53	21.33	
119-GTVA	08.09	08.09	01.13	01.30	01.19	01.25	
120-GTVA	08.09	08.09	03.42	04.24	03.48	04.21	
121-GTVA	08.09	08.09	08.00	09.05	08.02	09.01	
122-GTVA	08.09	08.09	11.15	2.14	111.16	12.13	RECORD OF GEO-DATA LOST
123-FSO	08.09	08.09	15.21	19.08	15.25	19.08	RCON/OFF:17.25-19.08 , TOF1:18.30 , TON2:18.31
124-GTVC	08.09	08.09	22.37	23.25	22.44	23.34	
125-GTVC	09.09	09.09	01.47	02.40	01.58	02.38	
126-GTVC	09.09	09.09	05.38	06.05	05.38	05.53	

TAB. 11.3.2: LIST OF TV-PROFILES (GARIMAS 2 - SO 39)

STATION	DATE FROM	DATE TO	TAPE ON	TAPE OFF	AT BOTTOM FROM	AT BOTTOM TO	REMARKS
127-GTVC	09.09	09.09	08.50	09.05	08.52	09.01	
128-GTVC	09.09	09.09	12.27	12.43	12.29	12.40	
129-GTVC	09.09	09.09	14.47	15.49	14.49	15.47	
130-FSO	09.09	09.09	19.14	23.01	19.15	23.00	RCON/OFF:21.50 TO 22.02 , TOF1:22.12 , TON2:22.14
131-GTVC	10.09	10.09	05.38	07.28	05.40	07.18	NO RECORD: 05.52 - 06.15
132-GTVC	10.09	10.09	10.15	13.48	10.16	13.43	TOF1:12.25 , TON2:12.27 , NO RECORD FROM 11.40 TO 11.49
133-FSO	10.09	10.09	16.24	22.12	16.27	22.11	RCON/OF:16.28-16.35 , 16.38-18.25 , TOF1:19.26 , TON2:19.30
134-GTVC	11.09	11.09	04.22	07.53	04.24	07.49	TOF1: 07.26 , TON2: 07.29
135-GTVC	11.09	11.09	10.46	12.41	10.48	12.37	NO RECORD: 12.09 - 12.12
137-FSO	12.09	12.09	02.30	05.22	02.34	05.22	
138-GTVA	12.09	12.09	08.43	09.37	08.45	09.32	
139-FSO	12.09	12.09	19.31	21.32	19.46	21.32	
140-FSO	13.09	13.09	02.30	05.45	02.33	05.45	TOF1: 04.21 , TON2: 04.22
141-GTVA	13.09	13.09	12.48	13.11	12.50	13.07	
142-FSO	13.09	13.09	18.04	20.04	18.10	20.04	
143-FSO	14.09	14.09	00.38	02.21	00.45	02.20	
144-FSO	14.09	14.09	16.17	18.57	16.19	18.57	
145-FSO	15.09	15.09	00.14	04.02	00.17	04.01	
146-GTVC	15.09	15.09	10.13	10.33	10.14	10.30	

TAB. 11.3.2: LIST OF TV-PROFILES (GARIMAS 2 - SO 39)

STATION	DATE FROM	DATE TO	TAPE ON	TAPE OFF	AT BOTTOM FROM	AT BOTTOM TO	REMARKS
147-GTVC	15.09	15.09	12.59	15.08	13.00	15.02	NO RECORD: 14.43 - 14.47
148-FSO	15.09	15.09	18.36	21.55	16.40	21.55	TOF1: 21.41 , TON2: 21.43
149-FSO	16.09	16.09	00.54	03.01	00.56	03.01	
150-GTVC	16.09	16.09	05.37	07.08	05.39	07.00	
152-FSO	21.09	21.09	19.13	21.53	19.20	21.52	
153-FSO	22.09	22.09	02.30	05.35	02.32	06.01	
154-FSO	22.09	22.09	17.43	22.38	17.45	22.38	TOF1: 20.47 , TON2: 20.51
155-FSO	23.09	23.09	03.18	06.15	03.24	06.13	
156-FSO	23.09	24.09	18.05	03.54	18.11	03.53	TOF1:21.04,TON2:21.06,TOF2:00.11,TON3:00.14,TOF3:03.19,TON4:03.21
157-FSO	24.09	25.09	16.41	00.38	16.45	00.37	TOF1:19.45,TON2:19.50,TOF2:22.55,TON3:22.56
162-FSO	27.09	27.09	00.13	04.00	00.16	04.00	TOF1:03.16 , TON2:03.18
165-FSO	27.09	27.09	18.48	21.00	18.51	20.53	TV-SYSTEM BREAKDOWN AT 20.53
166-FSO	28.09	28.09	01.08	02.19	01.11	02.19	
167-FSO	28.09	28.09	13.32	15.28	13.33	15.28	
168-GTVC	28.09	28.09	21.08	22.38	21.10	22.34	
169-GTVB	29.09	29.09	02.18	07.52	02.22	07.47	NO RECORD:5.41-6.02,TOF1:3.57,TON/OF2:3.58-7.24,TON3:7.30
170-GTVB	29.09	29.09	11.32	13.16	11.34	13.01	
171-GTVB	29.09	29.09	15.52	20.22	15.54	20.21	TOF1:18.57 , TON2:19.01
172-FSO	30.09	30.09	01.22	04.01	01.21	04.00	NO RECORD:01.23-02.20,BOT2:02.22

TAB. 11.3.2: LIST OF TV-PROFILES (GARIMAS 2 - SO 39)

STATION	DATE FROM	DATE TO	TAPE ON	TAPE OFF	AT BOTTOM FROM	AT BOTTOM TO	REMARKS
173-GTVB	30.09	30.09	09.05	10.10	09.06	10.05	
174-GTVB	30.09	30.09	13.03	15.58	13.04	15.57	TOF1:15.03 , TON2:15.04
176-FSO	01.10	01.10	01.01	03.57	01.12	03.57	NO RECORD:01.05 - 01.10
177-GTVC	01.10	01.10	07.56	08.13	08.00	08.06	
178-GTVB	01.10	01.10	14.55	19.48	14.56	19.48	TOF1:17.42 , TON2:17.44
179-FSO	02.10	02.10	00.46	02.59	00.52	02.56	
180-GTVB	02.10	02.10	06.57	07.58	06.59	07.51	
181-GTVA	02.10	02.10	11.32	13.05	11.34	12.58	
182-FSO	02.10	02.10	16.54	19.57	16.56	19.57	
183-FSO	02.10	03.10	23.42	03.39	00.07	03.37	TOF1:03.07 , TON2:03.08
184-GTVA	03.10	03.10	08.00	12.00	08.03	11.59	TOF1:11.05 , TON2:11.06
185-GTVA	03.10	03.10	15.15	16.02	15.17	16.01	
186-FSO	03.10	03.10	19.04	23.31	19.06	23.30	TOF1:22.11 , TON2:22.11
187-FSO	04.10	04.10	03.45	06.11	03.45	06.10	
188-GTVA	04.10	04.10	09.35	11.04	09.38	11.00	
189-GTVA	04.10	04.10	13.56	14.35	13.58	14.29	
190-FSO	04.10	04.10	19.27	22.23	19.35	22.23	
191-FSO	05.10	05.10	01.51	04.18	01.51	04.18	
193-FSO	05.10	05.10	18.18	22.47	18.22	22.47	TOF1:21.22,TON2:21.41

TAB. 11.3.2: LIST OF TV-PROFILES (GARIMAS 2 - SO 39)

STATION	DATE FROM	DATE TO	TAPE ON	TAPE OFF	AT BOTTOM FROM	AT BOTTOM TO	REMARKS
194-FSO	06.10	06.10	01.24	03.26	01.26	03.20	
196-GTVA	06.10	06.10	12.15	14.10	12.19	14.09	
197-FSO	06.10	06.10	21.12	23.39	21.13	23.39	
198-FSO	07.10	07.10	02.19	05.18	02.21	05.18	
199-FSO	07.10	07.10	14.57	16.49	14.59	16.49	
200-GTVC	08.10	08.10	00.55	03.19	01.06	03.18	NO RECORD:01.46 BIS 01.54
201-GTVA	08.10	08.10	07.14	08.55	07.15	08.57	
202-GTVA	08.10	08.10	11.50	13.53	11.51	13.52	
203-FSO	08.10	08.10	18.22	18.45	18.23	18.45	18.45 STATION TERMINATED , MALFUNCTION OF STROBES
204-GTVA	08.10	08.10	23.35	23.57	23.36	23.54	
205-GTVA	09.10	09.10	02.24	04.40	02.27	04.40	
206-FSO	09.10	09.10	09.03	10.52	09.05	10.51	
207-GTVA	09.10	09.10	13.39	14.38	13.41	14.32	
208-FSO	09.10	09.10	18.37	21.38	18.38	21.38	
209-GTVC	10.10	10.10	00.53	01.32	00.59	01.30	
210-GTVC	10.10	10.10	04.39	05.08	04.43	05.03	
211-FSO	10.10	10.10	08.25	09.42	08.30	09.41	
212-FSO	10.10	10.10	10.44	12.22	10.47	12.20	
213-GTVC	10.10	10.10	15.45	16.11	15.47	16.04	

TAB. 11.3.2: LIST OF TV-PROFILES (GARIMAS 2 - SO 39)

STATION	DATE FROM	DATE TO	TAPE ON	TAPE OFF	AT BOTTOM FROM	AT BOTTOM TO	REMARKS
214-FSO	11.10	11.10	02.02	04.40	02.03	04.40	
215-GTVC	11.10	11.10	09.33	11.05	09.34	11.01	
216-GTVC	11.10	11.10	15.24	18.33	15.26	18.33	TOF1:17.50,TON2:17.52,NO RECORD:16.33 TO
217-FSO	11.10	12.10	21.46	00.17	21.52	00.16	
219-GTVC	12.10	12.10	06.29	08.21	06.30	08.19	
220-GTVA	12.10	12.10	11.21	11.40	11.24	11.39	
221-GTVC	12.10	12.10	18.56	19.22	19.00	19.20	
222-FSO	12.10	13.10	22.36	02.47	22.38	02.47	TOF1:02.24,TON2:02.25,NO RECORD:00.24 TO 01.07
223-GTVC	13.10	13.10	06.22	07.24	06.23	07.18	DATA TRANSFER DISCONNECTED
224-GTVA	13.10	13.10	11.16	13.47	11.17	13.39	TOF1:12.55,TON2:12.56
225-FSO	13.10	13.10	16.52	20.29	16.57	20.29	TOF1:19.57,TON2:19.59
226-GTVC	14.10	14.10	00.24	02.12	00.27	02.06	
227-FSO	14.10	14.10	05.49	06.08	05.56	06.06	DATA TRANSFER DISCONNECTED
228-GTVC	14.10	14.10	22.02	22.21	22.06	22.21	

TAB. 11.3.3: CLASSIFICATION OF SEAFLOOR STRUCTURES (GEO-ON LINE DATA REGISTRATION)

VOLCANITES

L	=	Lava, not determined
P	=	Pillow lava, not determined
PL	=	Pillows, striated
PP	=	Pillows with protuberances
PI	=	Individual pillows in sediment covered area
PLS	=	Pillow and sheet lava
S	=	Sheet lava, not determined
SL	=	Lobated sheet lava
SN	=	Nodular sheet lava
SP	=	Platy sheet lava
SC	=	Curtain fold/ropy sheet lava
SS	=	Scrambled sheet lava
T	=	Talus
TP	=	Pillow talus
TS	=	Sheet lava talus
B	=	Breccia/brecciated volcanites

SEDIMENT

M0	=	No sediment; reflection at glass surfaces			
M1	=	Sediment dusting; sediment in interstitial spaces			
M2	=	Sediment cover in part;	P	:	< 30 %
			SL,SN,SS	:	< 50 %
			SP, SC	:	< 100 %
M3	=	Strong sediment cover	P	:	>30 %
			SL,SN,SS	:	>50 %
M4	=	Total sediment cover; no rock outcrops			

TECTONIC STRUCTURES

GC	=	Crack/small fissure
G	=	Fissure/gja
G, w, o	=	Fissure/gja, width (m), offset (m), (up + down -): G, 2,-4
GF	=	Flat floored fissure
GF, w, o	=	Flat floored fissure, width (m), offset (m) (up + down -): GF,5,+2
D	=	Displacement without fissure/crack
Do	=	Displacement with offset (< 3m) in m (up + down -):D+2
DA	=	Displacement assumed
DS	=	Scarp
DSo	=	Scarp with offset (> 3m) in m (up + down -): DS-10
DSA	=	Scarp assumed

TAB. 11.3.3: CONTINUATION

COLLAPSE STRUCTURES

CS	=	Collapse structure (small scale)
CP	=	Collapse structure (large scale); collapse pits, lava lakes

MORPHOLOGY

FF	=	Flow front
+-	=	Flat terrain
++	=	Slope upwards
--	=	Slope downwards

HYDROTHERMALISM

H	=	General indications
HH	=	Sulphides
HHH	=	Sulphides, large area
HP	=	Precipitates on cracks and volcanite surfaces
HSF	=	Silicate and ferronian precipitates on cracks
HF	=	Fauna
HFC	=	Crab
HFP	=	Pogonophora
HF, C, x	=	Special fauna (x)
HM	=	Sediment coloration; oxyhydroxides
HML	=	Light coloration
HMD	=	Strong coloration
HC	=	Crusts/oxyhydroxides
HA	=	Halo around rocks

FAUNA

FB	=	Benthos; sessil + vagrant
FE	=	Endobenthos/ichnofossils

COMMENTS

C, xyz	=	General comment (sub-position, distance ship-equipment, number of flashes and lights, number of photos, morphological and tectonical features, statements to function of TV-grab, etc.)
TON	=	Tape on
TOF	=	Tape off
BOT1	=	First bottom sight
BOP1	=	First bottom photo
LOB	=	Loss of bottom sight
BOT	=	Bottom sight again
UP	=	Heaving start
SAM, x	=	Sampling
RCON	=	Colour TV, record on
RCOF	=	Colour TV, record off
RBON	=	Black and white TV, record on
RBOF	=	Black and white TV, record off

TAB. 11.3.4: ON-LINE RECORD OF TV-OBSERVED GEOLOGICAL DATA

STATION : SO39-183FSO

TIME (GMT)	WATER DEPTH	CABLE LENGTH	
23:42:54	2532	2473	TON
00:07:53	2580	2569	BOT1,BOP1,T,M2,PL
00:10:10	2582	2539	C,NORTHERN SLOPE TERRACE
00:14:48	2533	2555	BOT,T
00:15:19	2522	2538	LOB
00:18:23	2586	2482	LOB
00:21:08	2539	2508	PL,M2,C,ON TOP
00:24:11	2536	2567	BOT,D-60,TP,M1
00:24:41	2538	2571	TP,M2
00:25:03	2584	2570	D+5
00:25:26	2584	2565	D+5
00:26:06	2534	2560	PP,PL,M3
00:27:51	2583	2557	PI,M3
00:33:25	2606	2564	PI,M3
00:37:44	2597	2585	M3,PI
00:39:53	2589	2593	C,BASIS SUEDWALL
00:41:57	2584	2589	M4
00:43:05	2594	2590	GC
00:43:19	2597	2588	G,0.5,0,M4,
00:43:53	2595	2587	G,1,C,M4
00:44:16	2580	2588	M4
00:45:22	2584	2585	M3,SS
00:46:57	2582	2584	HM,PI,M3
00:47:40	2580	2578	GC,FF,PL,M2
00:49:34	2580	2581	M4
00:51:45	2580	2582	SS,M3
00:52:29	2586	2582	M4
00:53:17	2581	2578	GC,S
00:54:01	2580	2577	GC
00:54:50	2539	2574	G,2,0
00:55:45	2590	2574	M4,LOB
00:59:03	2585	2564	BOT,LOB
01:01:28	2533	2541	LOB
01:02:57	2580	2565	BOT,C,WALL,M4
01:03:36	2586	2568	G,1,0
01:04:08	2533	2569	M3,PI,HM
01:05:28	2584	2567	M4
01:06:08	2530	2568	G,0.5,0,M4
01:07:28	2536	2566	G,0.5,0,M4
01:08:20	2536	2566	G,3,-1
01:09:17	2535	2567	M3,HM,PI
01:12:06	2594	2563	M4,HM
01:12:53	2538	2561	G,2,0,M4
01:14:08	2538	2560	G,1,C
01:15:12	2580	2559	G,0.5,0,M4
01:16:31	2581	2560	HM,M3,PL
01:18:12	2588	2559	HM,M3,SS
01:19:20	2600	2561	PI,HM,M3
01:20:27	2632	2561	HM,M3
01:20:37	2607	2561	PI,HM,M3
01:21:16	2600	2561	GC,PI,HM,M3
01:22:58	2604	2567	PI,HM,M3
01:25:00	2604	2579	PI,HM,M3
01:28:18	2594	2594	G,2,0,PI,HM,M3
01:29:18	2589	2595	TP,M2

01:30:22	2600	2594	G,1,0,PL,M3
01:33:23	2588	2606	G,1,0,HM,M3,PL
01:35:06	2591	2605	GC,D+1,PL,M3
01:37:01	2591	2605	G,2,0,PL,M3
01:41:08	2591	2614	PL,M3
01:42:39	2595	2615	G,2,0
01:43:07	2603	2616	G,2,0,PL,M3
01:44:45	2602	2616	PI,M3
01:48:10	2611	2617	G,0.5,0,PI,M3
01:49:33	2618	2621	GC
01:49:53	2610	2620	GC
01:56:03	2583	2637	M4
01:56:35	2538	2639	CS,SP,M3
01:59:43	2535	2646	CS,M3,PL
02:00:27	2517	2649	G,0.5,0,PL
02:01:11	2589	2651	M4
02:01:55	2517	2654	G,0.5,-1
02:02:24	2523	2657	PI,M3
02:03:56	2591	2661	PI,M3
02:07:15	2525	2667	PI,M3
02:10:17	2595	2673	SS,M3
02:11:09	2592	2677	PI,M3
02:12:44	2596	2668	++,M3,T,PI
02:13:31	2587	2659	PI,M3,++
02:15:29	2607	2633	HM,GC,M3,PL,++
02:15:57	2588	2631	PI,HM,M3,++
02:17:03	2587	2631	G,1,C,M3,PI
02:18:21	2583	2639	GC
02:19:10	2596	2639	PI,M3
02:20:27	2583	2637	M3,PL
02:21:17	2586	2632	G,2,+2
02:22:11	2583	2630	GC
02:23:10	2582	2631	GC
02:23:14	2582	2631	G,2,+1
02:23:36	2582	2630	M4
02:24:46	2584	2629	SS,M3
02:25:57	2586	2618	T,TP,M3,++
02:26:28	2536	2607	T,M3,LOB
02:27:45	2586	2594	LOB
02:28:08	2584	2595	BOT,HM,T,HH?
02:29:33	2538	2582	D+25
02:30:27	2587	2557	PL,M3
02:31:08	2591	2555	G,0.5,0
02:31:24	2580	2553	PL,M3
02:31:38	2535	2553	GC
02:32:01	2581	2549	PL,M3
02:32:47	2585	2543	G,D+,LOB
02:35:54	2580	2530	D-54
02:40:10	2528	2596	T,M2
02:42:34	2526	2593	TP,M2,M3,C,BASALT COLUMNS
02:50:11	2525	2563	T,M3
02:54:10	2582	2568	T,M3,M2
02:57:31	2527	2581	T,M2
03:00:44	2534	2594	M3,PI
03:02:19	2536	2603	FF,M3,SS,D+2
03:02:55	2537	2600	M3,SSD
03:06:09	2584	2594	D+6
03:07:15	2600	2596	C,TAPE 1 OFF

TAB. 11.3.4: CONTINUATION

03:08:24	2629	2584	C,TAPE 2 ON
03:08:34	2616	2587	LOB
03:08:50	2601	2590	BOT,--,M3,HM,PI
03:12:12	2631	2615	GC,PL,M3,HM
03:13:22	2633	2614	M3,PI
03:16:52	2600	2603	PI,M3,++
03:19:12	2605	2604	PL,M2
03:20:17	2606	2599	G,6,-5
03:21:32	2622	2604	D-6
03:22:31	2594	2610	--,PI,HM,T
03:23:53	2585	2604	LOB
03:25:28	2592	2612	BOT,TP,M3
03:28:24	2602	2602	T,M3
03:30:11	2609	2606	PL,TP,M3,C,AT SLOPE
03:33:54	2609	2627	--
03:34:42	2633	2638	T,--,M2
03:39:29	2632	2556	LOB
03:39:32	2632	2556	UP
03:39:33	2632	2556	TOF

11.4 Sediment Sampling and Sample Preparation

The metal dispersion from submarine hydrothermal sources influences the composition of deep-sea sediments, which are normally composed of biogenic, mainly calcareous and partly siliceous debris, and detrital minerals. The hydrothermal impact mainly consists of elements and compounds which are not fixed at the seawater-basalt boundary during growth of the sulfide chimneys, but are expelled into the water column above.

Especially Fe and Mn, as well as several trace elements, built up a significant metal dispersion halo along spreading centers and above all around active hydrothermal fields. Fe and Mn are predominantly precipitated as oxidic or hydroxide compounds and can be dispersed over tens to hundreds of kilometers according to the actual current pattern. Several trace elements can be enriched at Fe-Mn-oxyhydroxide surfaces by adsorption from seawater.

The sediment coring programme of GARIMAS 2 comprises 25 stations. The stations are placed along the Galapagos Rift from 85°28'W to 94°28'W, mostly by pairs north and south of the accretion axis, to account for the effects of the residual current transport (Fig. 11.4.1). To compare identical strata, the Reineck box corer was used for sampling the uppermost 40 cm of the sediment column without disturbances (Tab. 11.4.1). In one case the box corer (100 K) was employed. 21 coring attempts yielded sediment samples. On-board preparation of sediments for on-shore laboratory analyses was mainly restricted to wet-sieving procedures collecting different grain size fractions and to air-sealed storage of samples. Only during Leg 3 on-board chemical analyses were performed by K. Becker/P. Herzig of RWTH Aachen by aid of the x-ray-analyzer (see chapter 11.7).

The ship's time spent on the sediment sampling program amounts to 47 h or 1.8 % of GARIMAS 2.

The usual sediments encountered are foraminiferal nannofossil oozes (FNO) with detrital components and debris of siliceous organisms. The surface layer of the cores is in most cases light brown to medium brown coloured, indicating an enrichment of Fe-Mn-oxyhydroxide compounds. Higher concentrations, especially of manganese, can be attributed either to diagenetic remobilization in deeper layers and upward transport or to hydrothermal imprints from the water column. Whether the diagenetic or the hydrothermal imprint is more effective will be investigated at several Universities (Hamburg, Geologisches Institut: P.H. Tse; Aachen, RWTH: K. Becker; BGR: V. Marchig).

At two stations at least Mn-concentrations were determined so far, which cannot be traced back to normal diagenetic enrichments (72 GK, 100 K). At 72 GK values of 16.2 % Mn from 0 - 10 cm depth and 20.8 % Mn at 11 - 33 cm depth were analyzed. Another core (100 K), about 2 km west of 72 GK still showed 7.0 % Mn at the surface and 2.6 - 4.2 % Mn from 1 - 31 cm depth. Both cores were sampled about 12 km south of the actual accretion axis.

TV- and photo-profiles (138 FS, 138 GTVA, 141 GTVA) as well as additional sampling of the surface (138 GTVA, 141 GTVA) proved the existence of a large hydrothermal mound area within a sediment covered plain. Similar mounds consisting primarily of Mn-oxides and nontronitic clays have already been found at sites 506, 507 and 509 of Leg 70 (DSDP) at about 86°05 - 86°08 W/0°33 - 0°36 N. These mounds are located 20 to 30 km south of the Galapagos spreading center over crust 0.5 to 0.9 Ma in age (Honnorez et al., 1981).

TAB.11.4.1.: SEDIMENT STATIONS CARIMAS 2

STATION NO.	LATITUDE N DEG	LATITUDE N MIN	LONGITUDE W DEG	LONGITUDE W MIN	WATER-DEPTH(m)	DISTANCE AXIS(km)		RECOVERY (cm)	REMARKS
14 GK	0	47.023	85	28.212	2875	6.5	N	12	FNO
15 GK	0	40.866	85	28.583	2773	4.8	S	30	FNO,0-10 OXIDIC
22 GK	0	53.197	86	10.156	2710	9	N	17	FNO
23 GK	0	45.529	86	14.000	2880	6	S	650g	FNO
44 GK	0	41.895	86	07.304	2745	10	S	42	FNO,0-11 OXIDIC
45 GK	0	55.077	86	08.179	2674	15	N	41	FNO,0-12 OXIDIC
71 GK	0	58.528	86	58.848	2620	11	N	40	FNO,0-16 OX (1.9% MN)
72 GK	0	37.642	87	08.290	2704	12	S	33	MANGANIFEROUS OOZE (16-21% MN) AND MN-CRUSTS (35.9% MN)
73 GK	0	45.196	87	38.765	2335	9.3	N	16	FNO (0.16% MN)
74 GK	2	29.914	93	14.064	2445	8.3	N	40	FNO,0-14 OX(0.16% MN)
75 GK	2	22.697	93	15.842	2613	0.8	C	3	FNO + VOLCANIC GLASS
77 GK	2	16.831	93	17.080	2493	10	S	42	FNO,0-16 OX(0.30% MN)
84 GK	2	22.724	94	28.442	2576	11.1	S	40	FNO,0-15 OX(0.45% MN)
85 GK	2	40.479	94	28.674	2764	13.9	N	36	FNO,0-18 OX(0.48% MN)
98 GK	0	50.212	90	14.866	2200	5	S	300g	FNO (0.04% MN) AND BASALTIC GLASS CHIPS
99 GK	1	00.440	90	12.271	2090	15	N	41	FNO,0-10 OX(0.43% MN)
100 K300	0	37.132	87	09.333	2713	12	S	74	MANGANIFEROUS OOZE (4.2 - 7.0 % MN)
136 GK	0	58.316	86	30.505	2771	15	N	39	FNO,0-13 OXIDIC
151 GK	0	38.058	88	26.877	2450	8	S	41	FNO,0-14 OXIDIC
158 GK	1	51.101	90	59.308	2298	5	S	43	FNO,0-13 OXIDIC
159 GK	1	06.442	90	38.113	2249	13	N	2	FNO
160 GK	0	52.871	90	39.079	2236	12	S	38	FNO,0- 2 OXIDIC
161 GK	0	55.920	89	43.712	2109	15	N	40	FNO,0- 8 OXIDIC
163 GK	0	41.532	89	04.542	2281	13	S	28	FNO,0-17 OXIDIC
164 GK	0	48.330	88	26.500	2236	8	N	18	FNO,0-18 OXIDIC

GK = BOX CRAB

K = BOX CORER

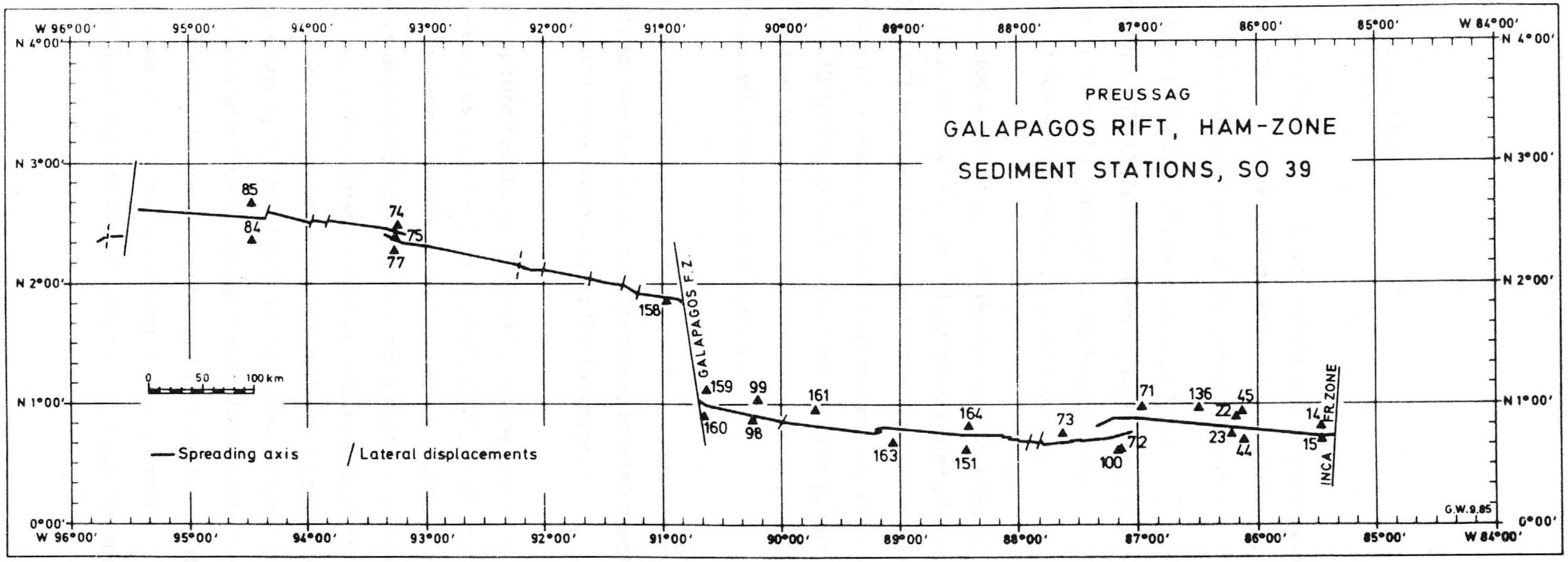


FIG. 11.4.1: LOCATION OF SEDIMENT SAMPLING STATIONS

11.5 Rock and Sulfide Sampling

The ship time devoted to the rock and sulfide sampling program amounts to 20 days and 18 hours or 19.2 % of the total GARIMAS 2 cruise time. Sampling was mainly performed by three different types of TV-controlled grabs:

- grappler-type (GTVC): 55 employments, 62 % successful
- clamshell-type (GTVA): 26 employments, 65 % successful
- fork-type (GTVB): 23 employments, 48 % successful

All GTV-Stations: 104 employments, 60 % successful.

A station was called successful, when recoveries exceeded 10 kg. A 60 % success-rate is a high value for this new type of sampling system, two of the grabs are prototypes (GTVB, GTVC) and were employed for the first time in marine exploration. The malfunctions due to mechanical or electrical reasons are even lower than 40 %: at 31 stations (= 30 %) the operation was interrupted resp. terminated without a recovery. In another 10 % of all stations the grabs were empty due to sampling attempts at slopes (tilted over) or non-suitable outcrops.

The chain-drege was placed at 21 locations. It was only employed, when TV-grabs were not ready for use due to technical reasons, or when morphological features voted for not taking a risk by employing the TV-grabs.

A list of stations performed during GARIMAS 2 for the task of rock or sulfide sampling is attached (see tables 11.5.1 - 11.5.3 GTVA, GTVB, GTVC and 11.5.4 Dredge). Volcanic rocks (basalts of MORB- or FeTi-type) were sampled to detect alterations and precipitates originating from hydrothermal activity, thus indicating prospective areas for a massive sulfide genesis. Massive sulfides and other hydrothermal products were recovered from known occurrences (GARIMAS 1 Locations A, B) and from new sites (Locations C, F). Main target of the sulfide sampling program was to collect sulfide ores from Location B statistically in order to evaluate the deposit potential and to provide material for processing tests. Therefore this location was covered with an ATNAV-navigation array consisting of 8 transponders. This array allowed for an accurate positioning of the TV-grab by aid of sub-transponders, attached at the TV-cable 50 m above the sampling device.

Sub-positioning outside the ATNAV-array was performed by an ultra-short base line system (RS 904) in combination with GPS- or SATNAV (Magnavox)-navigation.

Sampling points were chosen at known hydrothermal sites based on sulfide discoveries made on photo-profiles.
At location B the detailed bathymetric, tectonic and volcanological map, surveyed during GARIMAS 1, served as a useful tool to select prospective positions.
In reconnaissance areas sampling places were chosen on base of a tectonic interpretation of morphological data using bathymetric maps or Seabeam swathes.
After reaching the seafloor the ship slowly moved (less than 0.5 kn) across the chosen prospective zone. The grab-seafloor distance was controlled by TV and fixed at about 3 - 5 m. The actual positions of grab and ship were on-line plotted on a graphic-terminal. A second terminal was used for on-line recording of volcanic, tectonic and hydrothermal features observed. Since all investigated sulfide occurrences were inactive and partly covered by sediments, recognition was not very easy. Often volcanic structures of stack-like habitus were sampled instead of sulfidic chimneys. The experience to distinguish between both structures increased during GARIMAS 2. Especially the dark coloration of sediments around stack-like features later on served as an important criterion to select sulfide stacks. The coloration can be traced back to Fe-oxyhydroxides, either originating from late-hydrothermal low temperature emanations ore alteration/oxidation of sulfide edifices at the surface.
Following the sampling of a seafloor structure, the content of the grab was inspected a few hundred meters above the bottom after washing off accompanying sediments. In case the sampled material proved to be of volcanic nature the grab was reopened and the operation repeated. Nevertheless 30 stations of 104 resulted in the sampling of basaltic material (see Table 11.5.5). This high number reflects the difficulties to discriminate hydrothermal and volcanic edifices by black and white TV-observation.

In reconnaissance areas dredges were operated mainly up slope after advancing the ship about one mile from the position of bottom contact. To dredge sulfides within a known hydrothermal field, the dredge was thoroughly positioned within the field and subsequently towed only a short distance across the seafloor. Usually the position of the dredge was controlled by a pinger mounted 200 m above the instrument. Within the ATNAV-array a subtransponder was also attached.

During GARIMAS 2 a sum of 33.8 t of rocks, sulfides and other hydrothermal products were hoisted to the surface. The total weight of massive sulfides recovered amounts to 19.9 t, 17.389 kg of which are available for processing studies (MF-samples). 2511 kg of sulfides are distributed for geotechnical tests, chemical and mineralogical studies, or are stored as exhibition fragments or special pieces. Other hydrothermal products, oxidized sulfides, silica stacks, Fe-Mn-crusts, silicatic and/or oxidic metalliferous muds, sum up to 1484 kg. Samples prepared for on-shore investigations are summarized in Tab. 11.5.6. The remaining material consists of different types of basaltic lava and amounts to 12.416 kg. Only a small, but representative part of the basaltic fragments recovered has been stored for chemical and mineralogical investigations. The major part was thrown overboard and returned to the sea.

11.6 Technical Tests

Besides the already improved equipment such as Seabeam system, Multisonde, etc. some gears, which were partly new developed, were used during SO 39. Except for some short handling and function tests at the beginning of the cruise the equipment tests did not need any additional ship time, so that only 1.2 % of the ship time had to be devoted to test operations. Due to the fact that the new equipment worked without major problems from the beginning some minor tests could be combined with common station work. The main instruments which were tested during GARIMAS 2 were the TV-photo sledge and two TV-grabs.

TAB. 11.5.1: GTVA-STATIONS GARIMAS 2

STATION NO.	LATITUDE DEG	LATITUDE MIN	LONGITUDE DEG	LONGITUDE MIN	DEPTH M	SUB-POSITION	RECOVERY
SO 39 - 27 GTVA	N 0	45.985	W 85	55.011	2573	-	-
SO 39 - 35 GTVA	N 0	45.984	W 85	54.675	2539	-	5
SO 39 - 36 GTVA	N 0	46.018	W 85	54.703	2555	-	-
SO 39 - 37 GTVA	N 0	45.989	W 85	54.642	2574	-	33
SO 39 - 51 GTVA	N 0	45.987	W 85	54.635	2559	-	60
SO 39 - 66 GTVA	N 0	46.254	W 85	55.523	2609	-	-
SO 39 - 68 GTVA	N 0	46.197	W 85	55.606	2610	-	236
SO 39 - 119 GTVA	N 0	46.011	W 85	54.656	2582	-	600
SO 39 - 120 GTVA	N 0	45.985	W 85	54.663	2575	-	500
SO 39 - 121 GTVA	N 0	45.969	W 85	54.688	2565		1791
SO 39 - 122 GTVA	N 0	45.835	W 85	54.716	2570	-	200
SO 39 - 138 GTVA	N 0	38.389	W 87	08.389	2703	-	500
SO 39 - 141 GTVA	N		W		2707	-	400
SO 39 - 181 GTVA	N 0	46.045	W 85	54.626	2529	-	300
SO 39 - 184 GTVA	N		W		2512	-	-
SO 39 - 185 GTVA	N 0	46.168	W 85	54.693	2528	-	500
SO 39 - 188 GTVA	N 0	46.102	W 85	55.100	2535	-	350
SO 39 - 189 GTVA	N 0	45.965	W 85	54.921	2584	-	150
SO 39 - 196 GTVA	N 0	46.235	W 85	53.260	2605		15
SO 39 - 201 GTVA	N		W		2570	-	-
SO 39 - 202 GTVA	N 0	46.056	W 85	54.781	2568	-	353
SO 39 - 204 GTVA	N 0	44.950	W 85	50.641	2611	-	30
SO 39 - 205 GTVA	N		W		2613	-	-
SO 39 - 207 GTVA	N 0	46.039	W 85	54.594	2518	-	369
SO 39 - 220 GTVA	N		W		2604	-	-
SO 39 - 224 GTVA	N 0	45.895	W 85	54.594	2557		8

GTVA = TV-GRAB (kg)

TAB. 11.5.2: CTVB-STATIONS CARIMAS 2

STATION NO.	LATITUDE DEG	LATITUDE MIN	LONGITUDE DEG	LONGITUDE MIN	DEPTH M	SUB-POSITION	RECOVERY
SO 39 - 25 CTVB	N 0	46.096	W 85	55.016	2581	-	-
SO 39 - 30 CTVB	N 0	43.122	W 85	50.355	2635	-	80
SO 39 - 33 CTVB	N 0	45.020	W 85	50.607	2606	-	100
SO 39 - 34 CTVB	N 0	44.982	W 85	50.468	2554		180
SO 39 - 43 CTVB	N 0	44.980	W 85	50.271	2606	-	170
SO 39 - 102 CTVB	N 0	46.015	W 85	54.628	2574	-	672
SO 39 - 104 CTVB	N 0	46.0	W 85	54.7	2566	-	-
SO 39 - 106 CTVB	N 0	46.002	W 85	54.710	2554	-	423
SO 39 - 107 CTVB	N 0	46.018	W 85	54.635	2573	-	-
SO 39 - 109 CTVB	N		W		2577	-	-
SO 39 - 112 CTVB	N 0	45.996	W 85	54.843	2573	-	398
SO 39 - 113 CTVB	N 0	45.996	W 85	54.672	2554	-	-
SO 39 - 114 CTVB	N 0	46.123	W 85	53.443	2599	-	-
SO 39 - 115 CTVB	N 0	46.04	W 85	53.33	2608	-	-
SO 39 - 117 CTVB	N 0	46.000	W 85	54.593	2583	-	150
SO 39 - 118 CTVB	N 0	45.93	W 85	54.61	2577	-	-
SO 39 - 169 CTVB	N 0	46.0	W 85	54.7	2562	-	476
SO 39 - 170 CTVB	N 0	46.037	W 85	54.955	2574	-	70
SO 39 - 171 CTVB	N 0	45.963	W 85	54.603	2575	-	730
SO 39 - 173 CTVB	N		W		2588	-	-
SO 39 - 174 CTVB	N		W		2526	-	-
SO 39 - 178 CTVB	N		W		2539	-	-
SO 39 - 180 CTVB	N		W		2567	-	-

CTVB = TV-GRAB (kg)

TAB. 11.5.3: GTVC-STATIONS GARIMAS 2

STATION NO.	LATITUDE	DEG	MIN	LONGITUDE	DEG	MIN	DEPTH M	SUB-POSITION	RECOVERY
6 GTVC	N	0	46.169	W	85	54.933	2578	-	400
7 GTVC	N	0	46.138	W	85	53.738	2616	-	-
11 GTVC	N	0	45.939	W	85	54.753	2580	-	250
12 GTVC	N	0	46.117	W	85	53.901	2475	-	1200
16 GTVC	N	0	46.017	W	85	55.236	2566	-	20
17 GTVC	N	0	46.034	W	85	55.119	2572	-	-
20 GTVC	N	0	46.145	W	85	55.254	2576	-	-
21 GTVC	N	0	46.125	W	85	55.238	2584	-	1
38 GTVC	N	0	45.984	W	85	54.620	2577	-	2
39 GTVC	N	0	45.102	W	85	50.621	2597	-	225
40 GTVC	N	0	45.985	W	85	54.617	2577	-	50
41 GTVC	N	0	46.006	W	85	54.645	2574	-	1037
42 GTVC	N	0	45.990	W	85	54.628	2573	-	70
47 GTVC	N	0	44.984	W	85	50.701	2612	-	20
50 GTVC	N	0	46.015	W	85	54.640	2574	-	997
52 GTVC	N	0	45.995	W	85	54.636	2559	-	600
53 GTVC	N	0	45.991	W	85	54.640	2562	-	600
55 GTVC	N	0	45.984	W	85	54.713	2559	-	300
56 GTVC	N	0	45.993	W	85	54.670	2555	-	121
57 GTVC	N			W			2606	-	-
60 GTVC	N	0	45.959	W	85	54.753	2570	-	420
61 GTVC	N	0	45.000	W	85	50.490	2599	-	739
63 GTVC	N	0	46.060	W	85	54.631	2573	-	300
64 GTVC	N	0	45.962	W	85	54.781	2574	-	-
65 GTVC	N	0	46.000	W	85	54.870	2578	-	1109
101 GTVC	N	0	45.977	W	85	54.529	2582	-	-
103 GTVC	N	0	45.973	W	85	54.667	2577	-	-
108 GTVC	N	0	45.982	W	85	54.645	2570	-	-
124 GTVC	N	0	46.080	W	85	53.460	2603	-	350
125 GTVC	N	0	46.151	W	85	53.435	2606	-	10
126 GTVC	N	0	46.000	W	85	54.753	2579	-	3347
127 GTVC	N	0	45.992	W	85	54.772	2557	-	356
128 GTVC	N	0	46.023	W	85	54.744	2568	-	200
129 GTVC	N	0	45.997	W	85	54.778	2581	-	0.2
131 GTVC	N	0	46.033	W	85	54.860	2577	-	9.7
132 GTVC	N	0	46.07	W	85	54.87	2571	-	-
134 GTVC	N	0	46.021	W	85	54.940	2570	-	250
135 GTVC	N	0	46.001	W	85	54.851	2584	-	350
146 GTVC	N	0	45.983	W	85	54.782	2589	-	80
147 GTVC	N			W			2584	-	-
150 GTVC	N	0	46.00	W	85	54.8	2589	-	20
168 GTVC	N			W			2516	-	-
177 GTVC	N	0	45.889	W	85	54.785	2531	-	200
200 GTVC	N			W			2609	-	-
209 GTVC	N	0	45.627	W	85	52.046	2537	-	1
210 GTVC	N	0	45.689	W	85	54.622	2523	-	400
213 GTVC	N	0	45.978	W	85	54.602	2514	-	960
215 GTVC	N	0	46.123	W	85	54.742	2533	-	397
216 GTVC	N			W			2598	-	-
219 GTVC	N			W			2513	-	-
221 GTVC	N	0	44.957	W	85	50.734	2620	-	400
223 GTVC	N			W			2558	-	-
226 GTVC	N	0	45.001	W	85	50.707	2603	-	50
228 GTVC	N	0	46.724	W	85	58.435	2525	-	1480

GTVC = TV-GRAB (kg)

TAB. 11.5.4: DREDGE STATIONS CARIMAS 2

STATION NO.	LATITUDE DEG	MIN	LONGITUDE DEG	MIN	DEPTH M	SUB-POSITION	RECOVERY
SO 39 - 10 D	N 0	45.231	W 85	49.431	2659	-	150
SO 39 - 24 D	N 0	49.117	W 86	13.080	2495	-	28
SO 39 - 26 D	N 0	46.097	W 85	55.031	2573	-	280
SO 39 - 28 D	N 0	46.161	W 85	55.290	2585	-	25
SO 39 - 29 D	N 0	46.014	W 85	55.227	2566	-	400
SO 39 - 32 D	N 0	45.954	W 85	54.786	2584	-	353
SO 39 - 46 D	N 0	45.1	W 85	49.7	2581	-	15
SO 39 - 48 D	N 0	45.141	W 85	48.823	2635	-	700
SO 39 - 58 D	N 0	45.998	W 85	54.737	2574	-	360
SO 39 - 59 D	N 0	45.988	W 85	54.723	2580	-	600
SO 39 - 67 D	N 0	45.997	W 85	54.911	2558	-	400
SO 39 - 69 D	N 0	45.073	W 85	50.585	2572	-	1200
SO 39 - 79 D	N 2	36.389	W 94	49.347	2678	-	-
SO 39 - 80 D	N 2	36.401	W 94	49.388	2699	-	400
SO 39 - 82 D	N 2	35.871	W 94	53.400	2768	-	500
SO 39 - 90 D	N 2	35.605	W 94	47.955	2807	-	150
SO 39 - 91 D	N 2	37.382	W 94	59.152	2878	-	1200
SO 39 - 93 D	N 2	33.077	W 94	13.983	2513	-	-
SO 39 - 192 D	N 0	54.885	W 85	55.156	2590	-	5
SO 39 - 195 D	N 0	46.116	W 85	55.202	2574	-	30
SO 39 - 218 D	N 0	45.7	W 85	52.0	2623	-	300

D = DREDGE (kg)

TAB. 11.5.5: STATIONS WITH ROCK RECOVERY , GARIMAS 2

STATION NO.	LATITUDE DEG	MIN	LONGITUDE DEG	MIN	DEPTH M	RECOVERY
SO 39 - 6 GTVC	N 0	46.169	W 85	54.933	2578	SS,SP
SO 39 - 10 D	N 0	45.231	W 85	49.431	2659	FL
SO 39 - 11 GTVC	N 0	45.939	W 85	54.753	2580	SL,SP
SO 39 - 12 GTVC	N 0	46.117	W 85	53.901	2475	SS,SP
SO 39 - 24 D	N 0	49.117	W 86	13.080	2495	SL,SP
SO 39 - 26 D	N 0	46.097	W 85	55.031	2573	SS,SP
SO 39 - 28 D	N 0	46.161	W 85	55.290	2585	SP,SS,PP
SO 39 - 29 D	N 0	46.014	W 85	55.227	2566	SL
SO 39 - 30 GTVB	N 0	43.122	W 85	50.355	2635	FL
SO 39 - 32 D	N 0	45.954	W 85	54.786	2584	SL
SO 39 - 33 GTVB	N 0	45.020	W 85	50.607	2606	SL,SN
SO 39 - 34 GTVB	N 0	44.982	W 85	50.468	2554	FL,B(F)
SO 39 - 35 GTVA	N 0	45.984	W 85	54.675	2559	SS,SL
SO 39 - 37 GTVA	N 0	45.989	W 85	54.642	2574	SL
SO 39 - 39 GTVC	N 0	45.102	W 85	50.621	2597	SL,FL,SS
SO 39 - 40 GTVC	N 0	45.985	W 85	54.617	2577	SL
SO 39 - 42 GTVC	N 0	45.990	W 85	54.628	2573	FL
SO 39 - 46 D	N 0	45.1	W 85	49.7	2581	SL
SO 39 - 47 GTVC	N 0	44.984	W 85	50.701	2612	SS
SO 39 - 48 D	N 0	45.141	W 85	48.823	2635	FL,PP,SS
SO 39 - 51 GTVA	N 0	45.987	W 85	54.633	2559	SL
SO 39 - 52 GTVC	N 0	45.995	W 85	54.636	2559	SL,SP
SO 39 - 53 GTVC	N 0	45.991	W 85	54.640	2562	SL
SO 39 - 56 GTVC	N 0	45.993	W 85	54.670	2555	SL
SO 39 - 58 D	N 0	45.998	W 85	54.737	2574	SS
SO 39 - 59 D	N 0	45.988	W 85	54.723	2580	SS,SL
SO 39 - 63 GTVC	N 0	46.060	W 85	54.631	2573	FL
SO 39 - 67 D	N 0	45.997	W 85	54.911	2558	SL,FL
SO 39 - 69 D	N 0	45.073	W 85	50.585	2572	FL,SL,PP,SS
SO 39 - 75 GK	N 2	22.697	W 93	15.842	2613	volc. glass
SO 39 - 80 D	N 2	36.401	W 94	49.388	2699	SL
SO 39 - 82 D	N 2	35.871	W 94	53.400	2768	SL
SO 39 - 90 D	N 2	35.605	W 94	47.955	2807	PL,SL,SC
SO 39 - 91 D	N 2	37.382	W 94	59.152	2878	SL
SO 39 - 102 GTVB	N 0	46.015	W 85	54.628	2574	B(sulfidic)
SO 39 - 108 GTVC	N 0	45.982	W 85	54.645	2570	L (traces)
SO 39 - 114 GTVB	N 0	46.123	W 85	53.443	2599	SL(traces)
SO 39 - 117 GTVB	N 0	46.000	W 85	54.593	2583	L (traces)
SO 39 - 119 GTVA	N 0	46.011	W 85	54.656	2582	SS
SO 39 - 122 GTVA	N 0	45.835	W 85	54.716	2570	SS,SL
SO 39 - 128 GTVC	N 0	46.023	W 85	54.749	2568	SL,SS
SO 39 - 131 GTVC	N 0	46.033	W 85	54.860	2577	SL
SO 39 - 134 GTVC	N 0	46.021	W 85	54.940	2570	SS
SO 39 - 135 GTVC	N 0	46.001	W 85	54.851	2584	SS
SO 39 - 177 GTVC	N 0	45.889	W 83	54.785	2531	SS
SO 39 - 181 GTVA	N 0	46.045	W 85	54.626	2529	SS,SC
SO 39 - 191 FSO (S)	N 0	44.934	W 85	49.139	2508	FL
(E)	N 0	45.181	W 85	49.782	2616	
SO 39 - 192 D	N 0	54.885	W 85	55.156	2590	FL
SO 39 - 195 D	N 0	46.116	W 85	55.202	2574	SL
SO 39 - 196 GTVA	N 0	46.235	W 85	53.260	2605	SS
SO 39 - 210 GTVC	N 0	45.689	W 85	54.622	2523	FL
SO 39 - 218 D	N 0	45.7	W 85	52.0	2623	SL,SS,B
SO 39 - 221 GTVC	N 0	44.957	W 85	50.734	2630	SS
SO 39 - 226 GTVC	N 0	45.001	W 85	50.707	2603	B (sulfidic)

GTVA,GTVB,GTVC = TV-GRAB , D = DREDGE , GK = BOXGRAB , FSO = PHOTOSLEDGE

ABBREVATIONS SEE TABLE 11.3.3 , CHAPTER 11.3

TAB. 11.5.6: SAMPLE LIST GARIMAS 2: MASSIVE SULFIDES AND HYDROTHERMAL PRODUCTS

STATION	RECOVERY	SULFIDES					OXIDIZED SULFIDES				FE-MN-CRUSTS				BASALTS, SULFIDIC				
NO.	(kg)	CS	MF	DSA	DSB		CS	MF	DSA	DSB	CS	MF	DSA	DSB	CS	MF	DSA	DSB	
06 GTVC	10														1	-	1	1	
11 GTVC	75														-	1	2	2	
11 GTVC	2.2	2	-	2	2														
16 GTVC	20										3	2	3	3					
21 GTVC	0.6						4	-	4	4									
26 D	30						5	-	5	5									
28 D	5						6	-	6	6									
29 D	235						7	3	7	7									
32 D	3.6	9	-	9	-														
32 D	64						8	4	8	8									
34 GTVB	180														-	-	10	9	
35 GTVA	10														10	-	11	10	
37 GTVA	17	11	-	12	11														
	1						13	-	14	13									
38 GTVA	2						14	-	15	14									
41 GTVC	1037	15	5	16	15														
42 GTVC	20	16	6	17	16														
	8						17	7	18	17									
43 GTVB	116	17	8	18	17														
47 GTVC	20														18	-	19	18	
50 GTVC	997	19	9	20	19														
51 GTVA	60						20	10	21	20									
52 GTVC	1.4	21	-	22	-						-	-	24	25	-	-	23	21	A
53 GTVC	10	22	-	25	22														
	600						23	-	27	24					-	-	26	23	A
55 GTVC	251	24	11	28	26														
56 GTVC	121	25	12	29	27	S									26	-	30	28	
58 D	336	27	13	31	29	B													

TAB. 11.5.6 continuation: SAMPLE LIST GARIMAS 2: MASSIVE SULFIDES AND HYDROTHERMAL PRODUCTS

STATION NO.	RECOVERY (kg)	SULFIDES CS	MF	DSA	DSB	OXIDIZED SULFIDES CS	MF	DSA	DSB	FE-MN-CRUSTS CS	MF	DSA	DSB	BASALTS, SULFIDIC CS	MF	DSA	DSB	REMARKS
60 GTVC	420	28	14	33	30													
61 GTVC	759	29	15	34	31													
65 GTVC	1109	30	16	35	32	-	-	36	-									
68 GTVA	256									31	17	37	33 S					
102 GTVB	649	32	18	38	34													
106 GTVB	366	33	19	39.	35 B													
112 GTVB	344	35	20	42	36													
114 GTVB	0.5					36.	-	43.	-									
117 GTVB	83	36.	21	43.	37 S													
120 GTVA	30	37	-	44	38	-	22	-	- F									
121 GTVA	1791	38	23	45	39													
124 GTVC	350													-	-	46	40	SiO_2-Smoker
125 GTVC	10									-	-	47	41					
126 GTVC	3347	39	24	48	42													
127 GTVC	356	40	25	49	43													
128 GTVC	200					41	-	50	44									
129 GTVC	0.2					42	-	51	45									
134 GTVC	250									43	-	52	46					
135 GTVC	10									44	-	53	47					
141 GTVA	1					CC2	-	-	-	CC3	-	-	-					Mound area
146 GTVC	68	45	26	54	48													
150 GTVC	30									46	-	55	49					
169 GTVB	750	47	27	56	50													
170 GTVB	70	48	28	57	51													
171 GTVB	730	49	-	58	52													
177 GTVC	10									50	-	59	53					
181 GTVA	262									CC4	-	-	-	51	29	60	54	Silicate ooze
185 GTVA	337	52	30	61	55	53	-	62	56									
188 GTVA	350									54	-	63	57					
189 GTVA	71									55	31	64	58					

TAB. 11.5.6 continuation: SAMPLE LIST GARIMAS 2: MASSIVE SULFIDES AND HYDROTHERMAL PRODUCTS

STATION	RECOVERY	SULFIDES				OXIDIZED SULFIDES				FE-MN-CRUSTS				BASALTS, SULFIDIC				REMARKS
NO.	(kg)	CS	MF	DSA	DSB	CS	MF	DSA	DSB	CS	MF	DSA	DSB	CS	MF	DSA	DSB	
195 D	30									56	-	65	59					
202 GTVA	353	57	32	66	60	59	-	-	-									
		58	-	67	61													Zn-rich
207 GTVA	269	60	33	68	62													
209 GTVC	1									61	-	69	63					Mound?
210 GTVC	5									-	-	70	-					
213 GTVC	960	62	34	71	64													
215 GTVC	397	63	35	72	65													
224 GTVA	3									64	-	73	66					
228 GTVC	1480	65	36	74	67													

F = Mixed with sediment

S = Silica-dominated (Opal, Basalt?)

B = Sulfid-basalt breccia

A = Hydrothermally altered

. = numbers twice

11.7 Chemical and Mineralogical Analysis

. Instrumentation

For on-board analyses on massive sulphides and hydrothermally influenced sediments the x-ray fluorescence spectrometer Philips PW 1410 was applied. The determination of carbonates in sediments was done by applying the method of Müller and Kastner (1971).
During the first week the x-ray instrument exhibited strong changes in the measured impulse, so that quantitative results could not be gained. Only when cleaning the gas-flow counter the instrument could be used properly. After some small repairs and service work the x-ray spectrometer is now ready for future cruises.

. Sampling

Sampling was done with a box corer. The core was described and classified into different sections. From each section a 500 g sample was taken, dried, grinded and pressed into 40 mm ⌀ tablets.
From the partly more than thousand kilograms of single massive sulphide recoveries a representative sample of 2 to 3 kilograms (broken pieces) was taken. After pre-crushing with a hammer the sample was devided and a mixed sample of 300 - 500 g was dried and grinded. Herefrom a portion of about 15 g was pressed into a tablet. For quick analyses small pieces of drilling cores (25 mm ⌀) with a length of about 10 mm (12 pieces per sample) were dried and analysed each at the top and at the bottom side. From these 24 measurements the mean value was taken as a measure of contents. This analyzing method developed for a quick on site quality control was applied for the determination of Cu, Zn, Fe and S contents. The complete procedure from start of drilling to end of measuring lasted not more than 2 hours.
The method was tested on 4 stations. A comparison between the quick analyses and the standard analyses described above shows that there is a good agreement for Cu, Fe and S whereas the results for Zn do not fit (see Fig. 11.7.1). This may be explained by the fact that Zn mainly exists as sphalerite, which can mechanically be destroyed and washed out during drilling.

During the GARIMAS 2 cruise a number of 16 mean samples of massive sulphides were analyzed on board (Tab. 11.7.1). Some additionally performed qualitative analyses in some cases revealed a certain amount of Germanium. The on-board sediment analyses are presented in Tab. 11.7.2 and the analyses on Fe-Mn-crusts are compiled in Tab. 11.7.3.

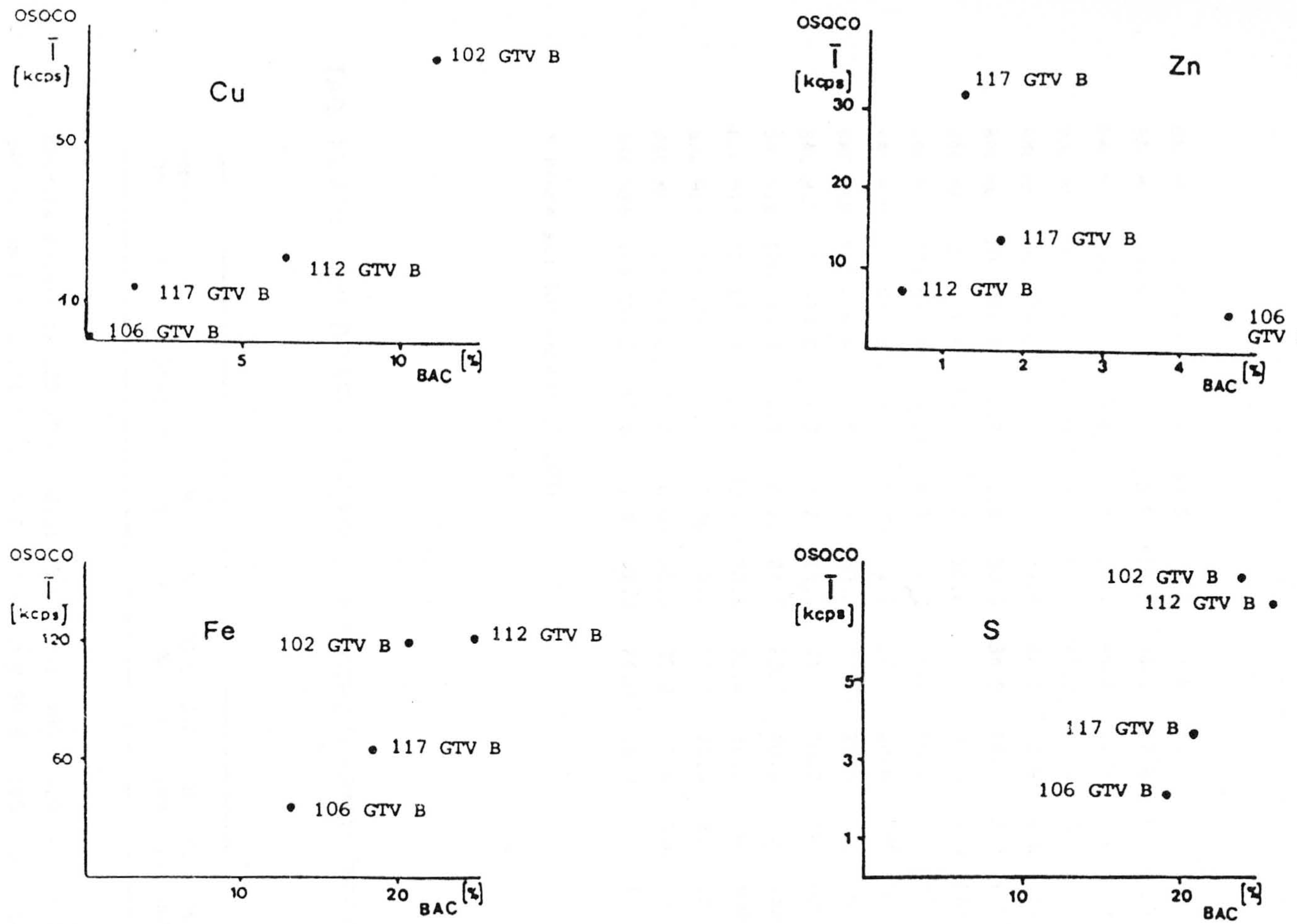


FIG. 11.7.1: COMPARISON BETWEEN THE QUICK ON SITE QUALITY CONTROL AND THE STANDARD ANALYSIS RESULTS

TAB. 11.7.1: SHIPBOARD ANALYSES ON MASSIVE SULPHIDES

Probe	Station	Cu %	Zn %	Fe %	S %	SiO_2 est.%	Mo ppm	Pb ppm	As ppm	Se ppm	Co ppm
BAC M1	50 GTV C	1.9	33.5	8.9	23.8	24.1	200	220	<50	<20	<40
BAC M2	58 DCB	0.25	2.9	29.9	34.1	27.8	140	960	140	<20	<40
BAC M3	60 GTV C	3.4	1.5	36.1	45.2	10.9	60	220	<50	<20	<40
BAC M4	61 GTV C	6.8	0.07	27.6	29.0	32.0	360	80	100	130	270
BAC M5	65 GTV C	7.4	1.2	35.9	44.0	3.9	110	270	130	160	270
BAC M6	102 GTV B	8.7	1.5	30.0	34.5	18.8	220	120	100	40	40
BAC M7*	102 GTV B	11.1	1.7	20.6	24.1	37.0	180	110	<50	40	80
BAC M8	106 GTV B	0.14	4.6	13.3	19.2	55.4	<20	390	<50	<20	<40
BAC M9*	112 GTV B	6.3	0.45	24.9	26	35.6	180	160	50	40	70
BAC M10	112 GTV B	6.8	0.15	30.4	33	22.8	250	80	110	60	230
BAC M11	117 GTV B	1.7	1.2	18.5	21	50.7	120	400	70	<20	<40
BAC M12	120 GTV A	0.39	0.24	27.7	20.6	40.3	90	130	70	<20	<40
BAC M13	121 GTV A	2.0	12.1	28.1	32.4	16.8	140	500	80	<20	<40
BAC M14	126 GTV C	2.1	0.05	34.2	32.3	21.9	310	120	160	50	130
BAC M15	127 GTV C	20.3	0.03	30.9	35.7	1.4	180	50	70	400	360
BAC M16	146 GTV C	19.6	1.9	22.2	24.0	25.9	260	100	<50	40	110

* Probe aus Bohrkernen (OSQCO)

TAB. 11.7.2: SHIPBOARD ANALYSES ON HYDROTHERMAL PRODUCTS

Probe: Nr.	Art	Station	Mn %	Fe %	CaO %	SiO_2 %	Mo ppm	Pb ppm	As ppm	Se ppm	Co ppm	Ni ppm
BACM12a	am.Silica	120 GTVA	0.01	5.0	<.1	>90	<20	<50	<50	<20	<40	<30
BAC 30	am.Silica mit Krusten	124 GTVC	9.2	12.7	0.8	69.3	120	<50	<50	<20	<40	30
BAC 30a	am.Silica	124 GTVC	0.02	1.8	<.1	>90	<20	<50	<50	<20	<40	<30
BAC 31	Mn-Kruste	125 GTVC	38.3	0.51	3.1	0.7	650	<50	<50	<20	<40	130
BAC 33	Mn-Kruste	134 GTVC	39.0	0.23	2.6	0.4	1300	<50	<50	<20	<40	90
BAC 34	Fe Fe/Mn-Oxyhydrox.	134 GTVC	31.4	12.0	2.7	9.8	1000	<50	<50	<20	<40	50
BAC 35	Mn-Kruste	135 GTVC	39.0	0.25	3.9	0.6	1400	<50	<50	<20	<40	160

TAB. 11.7.3 SHIPBOARD ANALYSES ON HYDROTHERMALLY INFLUENCED SEDIMENTS

Probe	Station	Profiltiefe (cm)	Mn %	Fe %	SiO_2 %	CaO %	Ni ppm	Co ppm	$CaCO_3$ %
BAC 1	71 GK	0-19	1.9	1.5	6.8	34.4	320	>30?	61.6
BAC 2	71 GK	16-22	0.11	2.2	19.2	41.2	70	<30	68.9
BAC 3	71 GK	22-40	0.07	1.6	18.8	40.6	70	<30	n.b.
BAC 4	72 GK	0-10	16.2	1.7	6.7	5.6	240	<30	n.b.
BAC 5	72 GK	11-33	20.8	2.4	15.0	21.7	330	<30	22.5
BAC 6	72 GK	Mn-Kr.	35.9	0.7	1.8	2.8	330	<30	n.b.
BAC 7	73 GK	0-16	0.16	1.0	14.1	41.9	40	<30	70.2
BAC 8	74 GK	0-14	0.16	0.8	12.8	46.8	40	<30	79.5
BAC 9	74 GK	15-40	0.08	0.7	12.6	48.1	20	<30	81.5
BAC 10	77 GK	0-16	0.28	0.8	16.6	43.4	60	<30	75.5
BAC 11	77 GK	16-23	0.05	0.9	15.4	45.8	20	<30	77.5
BAC 12	77 GK	23-42	0.02	0.7	15.5	46.2	20	<30	75.5
BAC 13	84 GK	0-15	0.45	1.0	14.7	40.4	90	<30	74.3
BAC 14	84 GK	15-28	0.26	1.1	15.8	43.6	50	<30	78.9
BAC 15	84 GK	28-40	0.03	0.8	14.4	44.6	30	<30	78.9
BAC 16	85 GK	0-18	0.48	1.1	14.1	42.2	80	<30	77.0
BAC 17	85 GK	18-29	0.44	1.0	12.2	44.3	80	<30	77.0
BAC 18	85 GK	29-36	0.05	1.1	14.8	45.4	40	<30	78.3
BAC 19	98 GK	Mischpr.	0.04	2.1	23.1	38.1	30	<30	66.0
BAC 20	99 GK	0-10	0.43	1.4	23.7	37.5	70	<30	65.3
BAC 21	99 GK	10-25	0.05	1.4	22.2	38.7	40	<30	69.3
BAC 22	99 GK	25-41	0.05	1.8	24.3	36.4	40	<30	64.7
BAC 23	100 K	Top	7.0	1.7	23.0	28.7	340	<30	44.0
BAC 24	100 K	0-6	4.2	1.5	24.4	32.5	269	<30	52.0
BAC 25	100 K	6-31	2.6	1.5	24.4	34.4	284	<30	60.0
BAC 26	100 K	31-54	0.59	2.0	25.5	34.5	170	<30	62.7
BAC 27	100 K	54-74	0.43	3.5	33.0	31.6	150	<30	54.7
BAC 28	120 GTVA		0.82	6.3	31.8	27.7	70	<30	35.1
BAC 29	122 GTVA		0.52	2.9	22.0	35.9	70	<30	52.7
BAC 39	136 GK	Top	2.6	1.9	23.5	32.7	340	<30	56.1
BAC 36	136 GK	0-13	1.4	1.8	23.8	34.1	190	<30	59.5
BAC 37	136 GK	13-24	0.39	2.1	22.7	36.6	100	<30	70.9
BAC 38	136 GK	24-39	0.13	2.1	23.1	36.7	110	<30	68.2
BAC 40	141 GTVA	Surface	0.50	21.5	46.3	4.5	40	40	<5.0
BAC 41	141 GTVA	0-5	3.3	1.7	23.5	33.8	280	<30	56.8
BAC 42	141 GTVA	6-14	2.6	2.1	21.0	34.6	240	<30	61.5
BAC 43	141 GTVA	15-60	0.40	2.4	27.8	34.1	140	<30	61.5
BAC 44	141 GTVA	Top	0.21	23.7	44.3	1.2	20	50	<5.0

11.8 Sulphide Sample Preparation and Geotechnical Tests

Massive sulphide samples were obtained at 33 stations during GARIMAS 2 (Table 11.8.7). The sample amount varies considerably from 1.4 kg to 3347 kg. Depending on the total amount of sample recovered different on-board preparation procedures were applied. Several large sulphide boulders were not cut and subsampled but were stored in total for further shore-based investigations:

121 GTVA:	2 blocks, 800 and 850 kg
126 GTVC:	1 block, 3280 kg
169 GTVB:	1 block, 274 kg
171 GTVB:	1 block, 730 kg.

If the sample amount exceeded 20 kg plastic bags were filled with the crushed material. This material (MF-series) will be used for processing investigations to be performed in on-shore laboratories (see Table 11.8.5).

Sulphide Sample Preparation

The sulphides were described and subsequently sub-sampled for various determinations and tests. On-board chemical analyses were only performed during legs 3 and 4. For preparation of this material see chapter 11.7. For chemical and mineralogical work several sub-samples were prepared and stored in plastic bags:

DSA	Documentation, PREUSSAG
DSB	" "
HDS	University Heidelberg, Institute for Sediment Research (K. Eilmes, P. Stoffers); representative sample and alteration products.
ACS	University Aachen, Department of applied deposit research (W. Plüger, P. Herzig, K. Becker); representative sample.
CS	PREUSSAG; representative sample for chemical analysis.
IHS	University Hamburg; Institute for Hydrobiology (Dr. Karbe); 10 samples for ecotoxicological tests.
SP	PREUSSAG; exhibition samples
MF	PREUSSAG; bulk samples for processing studies.

In addition to ship-board preparatory work shore-based sample preparation was performed (Tables 11.8.1 - 11.8.4). CS- and MF-samples were crushed to cm-size gravel (CSM- and MFM-samples) and furthermore grinded to analytical grade powder of less than 125 µm grain size (CSC- and MFC-samples).
Average regional samples for chemical analyses were prepared by mixing of aliquot parts of CSC/MFC-station samples. 5 regional samples have been obtained:

FA: consisting of station 228 GTVC only
AA: average of location A (stations 43 GTVB, 61 GTVC)
B1A: basalt and silica rich samples of location B (56 GTVC, 58 D, 106 GTVB, 117 GTVB)
B2A: 5 samples north of 0°46.03'N, location B, Cu-rich
B3A: 19 samples south of 0°46.03'N, location B, Zn-rich.

A similar set of regional samples was prepared for mineralogical investigations (FM, AM, B1M, B2M, B3M).

Tables 11.8.1 - 11.8.4 inform about samples of massive sulphides prepared for on-shore chemical and mineralogical investigations.
In addition they contain the distribution and mixing code.

Table 11.8.6 summarizes the information on institutions, participating in chemical and mineralogical determinations.

Geotechnical Tests

- Density Test

The density of sulphide material from 7 different sample stations (with 5 to 7 different pieces each station) was measured. The measurements were carried out with a special density balance.

Measurement description:
First the sample was mounted on the balance with a wire. Then the balance was adjusted on the zero point of their scale. After that the whole sample was immersed in water with the density 1 g/cm^2 and the density of the sample could be read directly from the scale.

The principle of the measurement is that the density of a solid can be calculated, if its weight in a liquid with known density and its normal weight in air is known.

A problem of this method was that all sulphide material was more or less porous. That means that there was always a certain amount of air-bubbles within the sample during weighing in water. The positive buoyancy of the air in water caused uncorrect density values so that the results listed in Table 11.8.8 can be taken only as a first estimation. Further density determinations will be carried out together with additional tests and measurements within home laboratories.

- The Point-load Strength Test

During GARIMAS 2 a number of 136 point-load strength measurements were carried out. The test procedure was as follows: A sample of sulphide material was sticked between two rounded cones. Then the pressure on the sample was increased by raising the lower cone by hydraulic power until the cylindric sample burst. The burst-power was recorded from the analog display of a manometer which was attached to the hydraulic power device.
As samples only cylinders with a diameter of 51 mm were used. Its length varied between 50 to 200 mm. The cylinders were produced by drilling cores out of the sampled sulphide blocks.
The performance of the point-load tests caused no problems and was very quick. The results obtained from these tests deliver a statistical distribution of point-load strengths which can be taken as guiding values for more accurate measurements, which will be carried out within home laboratories.
The test results are listed in Table 11.8.9.

TAB. 11.8.1: SAMPLES OF MASSIVE SULFIDES PREPARED FOR ON-SHORE CHEMICAL AND MINERALOGICAL DETERMINATIONS

STATION	CSC *	MFC *	MFM x	DSA x	DSB x	CS x
11 GTVC	2 *	-	-	2	2	-
32 D	9 *	-	-	9	-	-
37 GTVA	11 *	-	-	12	11	-
41 GTVC	15 *	-	-	16	15	-
42 GTVC	-	6 *	6	17	16	16
43 GTVB	-	8 *	8	18	17	17
50 GTVC	-	9 *	9	20	19	19
52 GTVC	21 *	-	-	22	-	-
53 GTVC	22 *	-	-	25	22	-
55 GTVC	-	11 *	11	28	26	24
56 GTVC	25 *	12 * s	12 s	29	27	-
58 D	-	13 * b	13 b	31	29	27
60 GTVC	28 *	-	-	33	30	-
61 GTVC	-	15 *	15	34	31	29
65 GTVC	-	16 *	16	35	32	30
102 GTVB	-	18 *	18	38	34	32
106 GTVB	33 *	19 * b	19	39	35	-
112 GTVB	-	20 *	20	42	36	35
117 GTVB	36 *	21 * s	21	43	37	-
120 GTVA	37 *	-	-	44	38	-
121 GTVA	-	23 *	23	45	39	38
126 GTVC	-	24 *	24	48	42	39
127 GTVC	-	25 *	25	49	43	40
146 GTVC	-	26 *	26	54	48	45
169 GTVB	-	27 *	27	56	50	47
170 GTVB	-	28 *	28	57	51	48
171 GTVB	49 *	-	-	58	52	-
185 GTVA	-	30 *	30	61	55	52
202 GTVA	-	32 *	32	67	61	58
207 GTVA	-	33 *	33	68	62	60
213 GTVC	-	34 *	34	71	64	62
215 GTVC	-	35 *	35	72	65	63
228 GTVC	-	36 *	36	74	67	65

Remarks: * = powder, grain size less than 125 µm; x = gravel, cm-size

s = silica dominated (opal, basalt?); b = breccia, sulfide-basalt

TAB. 11.8.2: DISTRIBUTION OF AVERAGE STATION SAMPLES FOR CHEMICAL AND MINERALOGICAL ANALYSES

	CHEMISTRY					MINERALOGY			
STATION	CSC*	MFC*	AC*	KA*	IC*	MFM+	DSB+	CN+	AC+
11	2		100 g each of CSC- and MFC-Samples	100 g each of CSC- and MFC-Samples	100 g each of CSC- and MFC-Samples		2	10 pieces each of MFM-Samples and total DSB	10 pieces each of MFM-Samples
32	9						–		
37	11						11		
41	15						15		
42		6				6			
43		8				8			
50		9				9			
52	21						–		
53	22						22		
		11				11			
56	25	12				12	27		
58		13				13			
60	28						30		
61		15				15			
65		16				16			
102		18				18			
106	33	19				19	35		
112		20				20			
117	36	21				21	37		
120	37						38		
121		23				23			
126		24				24			
127		25				25			
146		26				26			
169		27				27			
170		28				28			
171	49						52		
185		30				30			
202		32				32			
207		33				33			
213		34				34			
215		35				35			
228		36				36			

AC = Aachen University; KA = Karlsruhe University; IC = Imperial College London; CN = CNRS, Gif Sur Yvette, France
* : powder; + = gravel

TAB. 11.8.3: PREPARATION AND DISTRIBUTION OF AVERAGE REGIONAL SAMPLES (CHEMISTRY)

			PREPARATION					DISTRIBUTION			
STATION	LOC.	SAMPLE	AA	B1A	B2A	B3A	FA	AC	KA	IC	PR
			200 g	150	150	50	200 g	AA–B3A: 100 g each	AA–B3A: 100 g each	AA–FA: 100 g each	AA–FA: 100 g each
11	B3	CSC2				–					
32	B3	CSC9				+					
37	B3	CSC11				+					
41	B3	CSC15				+					
42	B3	MFC6				+					
43	A	MFC8	+			–					
50	B3	MFC9				+					
52	B3	CSC21				–					
53	B3	CSC22				+					
55	B3	MFC11				+					
56	B1	MFC12		+		–					
58	B1	MFC13		+		–					
60	B3	CSC28				+					
61	A	MFC15	+			–					
65	B3	MFC16				+					
102	B3	MFC18				+					
106	B1	MFC19		+		–					
112	B3	MFC20				+					
117	B1	MFC21		+		–					
120	B3	CSC37				+					
121	B3	MFC23				+					
126	B3	MFC24				+					
127	B3	MFC25				+					
146	B3	MFC26				+					
169	B3	MFC27				+					
170	B2	MFC28			+	–					
171	B3	CSC49				+					
185	B2	MFC30			+	–					
202	B2	MFC32			+	–					
207	B2	MFC33			+	–					
213	B3	MFC34				+					
215	B2	MFC35			+	–					
228	F	MFC36				–	+				

B1A: basalt and silica rich
B2A: north of 0°46.03'N
B3A: south of 0°46.03'N

AC = Aachen University; KA = Karlsruhe University; IC = Imperial College London; PR = Preussag Goslar

TAB. 11.8.4: PREPARATION AND DISTRIBUTION OF AVERAGE REGIONAL SAMPLES (MINERALOGY)

			PREPARATION					DISTRIBUTION	
STATION	LOC.	SAMPLE	AM	B1M	B2M	B3M	FM	IC	CL
			5 pieces of each station sample						
42	B3	MFM 6				+		AM–B3M: total ; FM: 10 pieces	AM–B3M: total ; FM: 10 pieces
43	A	MFM 8	+						
50	B3	MFM 9				+			
55	B3	MFM 11				+			
56	B1	MFM 12		+					
58	B1	MFM 13		+					
61	A	MFM 15	+						
65	B3	MFM 16				+			
102	B3	MFM 18				+			
106	B1	MFM 19		+					
112	B3	MFM 20				+			
117	B1	MFM 21		+					
121	B3	MFM 23				+			
126	B3	MFM 24				+			
127	B3	MFM 25				+			
146	B3	MFM 26				+			
169	B3	MFM 27				+			
170	B2	MFM 28			+				
185	B2	MFM 30			+				
202	B2	MFM 32			+				
207	B2	MFM 33			+				
213	B3	MFM 34				+			
215	B2	MFM 35			+				
228	F	MFM 36					+		

IC = Imperial College London; CL = Clausthal University

TAB. 11.8.5: MASSIVE SULFIDES FOR PROCESSING AND GEOTECHNICAL TESTS

STATION	MF(SULFIDE)	MF (OTHERS)	SULFIDE (NOT MF)	LOCATION
11 GTVC		MF 1) 1 DRUM 75 KG BASALTS, SULFIDIC	2.2 KG	B
16 GTVC		MF 2) 20 KG EX-SULFIDES		B
29 D		MF 3) 1 DRUM 235 KG EX-SULFIDES		B
32 D		MF 4) 1 DRUM 64 KG EX-SULFIDES	3.6 KG	B1
37 GTVA			17 KG	B1
41 GTVC	MF5) 1037 KG			B1
42 GTVC	MF6) 20 KG	MF7) 8 KG EX-SULFIDES		B1
43 GTVB	MF8) 116 KG			A
50 GTVC	MF9) 997 KG			B1
51 GTVA		MF10) 60 KG EX-SULFIDES		B1
52 GTVC			1.4 KG	B1
53 GTVC			10 KG	B1
55 GTVC	MF11) 251 KG			B1
56 GTVC	MF12) 121 KG	(SILICA DOMINATED)		B1
58 D	MF13) 336 KG	(BRECCIA, BASALTIC)		B1
60 GTVC	MF14) 420 KG			B1
61 GTVC	MF15) 759 KG			A
65 GTVC	MF16) 1109 KG			B1
68 GTVC		MF17) 2 DRUMS 256KG FE-MN-OXIHYDROXIDE		B
102 GTVB	MF18) 649 KG		GTB 23 KG	B1
106 GTVB	MF19) 366 KG	(BRECCIA, BASALTIC)	GTB 57 KG	B1
112 GTVB	MF20) 344 KG		GTB 54 KG	B1
117 GTVB	MF21) 83 KG	(SILICA DOMINATED)		B1
120 GTVA		MF 22) 1 DRUM 441KG EX-SULF. + SEDIMENT		B1
121 GTVA	MF23) 141 KG + 2 BLOCKS 850KG, 800KG			B1

124 GTVC		SP 32 SIO2-STACK		C
126 GTVC	MF24) 67 KG 1 BL.3280 KG			B1
127 GTVC	MF25) 356 KG			B1
146 GTVC	MF26) 68 KG			B1
169 GTVB	MF27) 476 KG 1 BL. 274 KG			B1
170 GTVB	MF28) 70 KG			B1
171 GTVB	1 BL. 730 KG	(EXHIBTION)		B1
181 GTVA		MF29) 262 KG SILICATIC MUD		B1
185 GTVA	MF30) 337 KG			B1
189 GTVA		MF31) 71 KG FE-MN-OXIHYDROXIDE		B1
202 GTVA	MF32) 353 KG			B1
207 GTVA	MF33) 269 KG			B1
213 GTVC	MF34) 833 KG		SP 47-54) 127 KG	B1
215 GTVC	MF35) 397 KG			B1
228 GTVC	MF36)1480 KG			F
TOTAL:	17.389 KG	1.484 KG	295 KG	

TAB. 11.8.6: CHEMICAL AND MINERALOGICAL ANALYSES OF MASSIVE SULFIDES, GARIMAS 2. (ON-SHORE LABORATORIES.)

A. CHEMICAL ANALYSES

1. Major element chemistry of individual stations (33 samples):
   - sample numbers: CSC 2-49, MFC 6-36
   - elements to be determined: Ag, Al, Ba, Ca, Co, CO_2, Cu, Fe, K, Mg, Mn, Mo, Na, P_2O_5, Pb, S^{2-}, SO_3, SiO_2, Ti, Zn
   - laboratories to be supplied (100 g each): RWTH Aachen, K. Becker; Uni Karlsruhe, Prof. Dr. H. Puchelt; Imperial College London, Dr. A.J. B. Mill; Studiengesellschaft für Eisenerzaufbereitung, Dr. Mertins

2. Major and trace element chemistry of average regional samples (5 samples):
   - sample numbers AA, B1A, B2A, B3A, FA (FA = MFC 36)
   - elements to be determined: same elements as listed above (A.1.), in addition: Cr, Hg, Ni, Rb, Sc, Sn, Sr, U, V, Y, Rare Earth
   - laboratories (100 g each): RWTH Aachen, K. Becker; Uni Karlsruhe, Prof. Dr. H. Puchelt; Imperial College, Dr. A.J. B. Mill

3. Trace element chemistry (valuable metals) of average regional samples (5 samples):
   - sample numbers AA, B1A, B2A, B3A, FA (FA = MFC 36)
   - elements to be determined: Ag, Au, As, Bi, Cd, Ga, Ge, In, Nb, Sb, Se, Te, Ta
   - laboratories (100 g each): Imperial College London, Dr. A.J.B. Mill; Preussag Metall Goslar, Dr. Wunderlich

4. S-Isotope determinations (33 samples)
   - sample numbers CSC 2-49, MFC 6-36
   - laboratory (20 g): Uni Karlsruhe, Prof. Dr. H. Puchelt

5. Age-determinations (31 samples); $^{230}Th/^{234}U$-method
   - sample numbers MFM 6-36, DSB 2-52
   - laboratory (200 - 300 g): CNRS, Gif sur Yvette, C. Lalou

6. Chemistry of silica-chimneys (124 GTVC)
   - laboratory: Heidelberg University, Prof. Dr. P. Stoffers.

TAB. 11.8.6 continuation: CHEMICAL AND MINERALOGICAL ANALYSES OF MASSIVE SULFIDES, GARIMAS 2. (ON-SHORE LABORATORIES.)

B. MINERALOGICAL ANALYSES

1. Qualitative ore microscopy or x-ray diffraction (24 samples):
   - sample numbers MFM 6-36
   - laboratory (200 - 300 g): RWTH Aachen, K. Becker.

2. Quantitative ore microscopy of average regional samples (5 samples)
   - sample numbers (AM, B1M, B2M, B3M, FM (FM = MFM 36)
   - laboratory (500 g): Universität Clausthal, Prof. Dr. P. Halbach; Imperial College London, Dr. A.J.B. Mill

3. Quantitative mineralogy of silica chimneys (124 GTVC)
   - laboratory: Heidelberg University, Prof. Dr. P. Stoffers.

TABLE 11.8.7: GARIMAS 2 STATIONS WITH SULPHIDE RECOVERY

STATION NO.	LATITUDE	DEC	MIN	LONGITUDE	DEC	MIN	DEPTH M	RECOVERY
11 GTVC	N	0	45.939	W	85	54.753	2580	250
32 D	N	0	45.954	W	85	54.786	2584	353
37 GTVA	N	0	45.989	W	85	54.642	2574	32
41 GTVC	N	0	46.006	W	85	54.645	2574	1037
42 GTVC	N	0	45.990	W	85	54.628	2573	70
43 GTVB	N	0	44.980	W	85	50.271	2606	170
50 GTVC	N	0	46.015	W	85	54.640	2574	997
52 GTVC	N	0	45.995	W	85	54.636	2559	600
53 GTVC	N	0	45.991	W	85	54.640	2562	600
55 GTVC	N	0	45.984	W	85	54.713	2559	300
56 GTVC	N	0	45.993	W	85	54.670	2555	121
58 D	N	0	45.998	W	85	54.737	2574	360
60 GTVC	N	0	45.959	W	85	54.733	2570	420
61 GTVC	N	0	45.000	W	85	50.490	2599	759
65 GTVC	N	0	46.000	W	85	54.870	2578	1109
102 GTVB	N	0	46.015	W	85	54.628	2574	672
106 GTVB	N	0	46.002	W	85	54.710	2554	423
112 GTVB	N	0	45.996	W	85	54.843	2573	378
117 GTVB	N	0	46.000	W	85	54.593	2583	150
120 GTVA	N	0	45.985	W	85	54.663	2575	500
121 GTVA	N	0	45.969	W	85	54.688	2565	1791
126 GTVC	N	0	46.000	W	85	54.753	2579	3347
127 GTVC	N	0	45.992	W	85	54.772	2557	356
146 GTVC	N	0	45.983	W	85	54.782	2589	80
169 GTVB	N	0	46.0	W	85	54.7	2562	476
170 GTVB	N	0	46.037	W	85	54.955	2574	70
171 GTVB	N	0	45.963	W	85	54.603	2575	730
185 GTVA	N	0	46.168	W	85	54.693	2528	500
202 GTVA	N	0	46.056	W	85	54.781	2568	353
207 GTVA	N	0	46.039	W	85	54.594	2515	269
213 GTVC	N	0	45.978	W	85	54.602	2514	960
215 GTVC	N	0	46.123	W	85	54.742	2533	397
228 GTVC	N	0	46.724	W	85	58.435	2525	1480

GTVA, GTVB, GTVC = TV-GRAB (kg)
D = DREDGE (kg)

TAB. 11.8.8:

DICHTE.DAT;2 17-OCT-1985 16:06 Page 1

DICHTEBESTIMMUNG VON SULFIDEN

STATION		DICHTE
S039 - 65 GTVC	PROBE 1:	2.3
	PROBE 2:	2.7
	PROBE 3:	2.65
	PROBE 4:	2.75
	PROBE 5:	2.5
S039 - 50 GTVC	PROBE 1:	2.6
	PROBE 2:	2.2
	PROBE 3:	2.4
	PROBE 4:	2.3
	PROBE 5:	2.4
S039 - 102 GTVB	PROBE 1:	2.75
	PROBE 2:	2.7
	PROBE 3:	2.65
	PROBE 4:	2.45
	PROBE 5:	2.6
S039 - 169 GTVB	PROBE 1:	3.4
	PROBE 2:	3.05
	PROBE 3:	3.05
	PROBE 4:	3.3
	PROBE 5:	3.0
	PROBE 6:	3.0
	PROBE 7:	3.0
S039 - 213 GTVC	PROBE 1:	2.27
	PROBE 2:	2.9
	PROBE 3:	2.56
	PROBE 4:	2.68
	PROBE 5:	2.25
	PROBE 6:	2.22
S039 - 215 GTVC	PROBE 1:	3.45
	PROBE 2:	3.45
	PROBE 3:	3.54
	PROBE 4:	3.4
	PROBE 5:	3.5
	PROBE 6:	3.26
	PROBE 7:	2.83
S039 - 228 GTVC	PROBE 1:	3.2
	PROBE 2:	3.3
	PROBE 3:	3.05
	PROBE 4:	3.2
	PROBE 5:	3.1
	PROBE 6:	2.8

TAB. 11.8.9: MEASURED VALUES OF POINT-LOAD STRENGTH TESTS

SAMPLE NO.	LENGTH mm	RANGE kN	POINT-LOAD STRENGTH kN	PENETR. mm	REMARKS
50 CTVC					
GTS A1 a	70	3	0.5	20	INHOMOGENIOUS
GTS A1 b	70	3	2.25	27.5	
GTS A4.2	60	3	2.7	26	
GTS A5.2	30	3	> 3	?	OUT OF RANGE
GTS A6 a	160	3	~ 3.5	6	OUT OF RANGE
GTS A6 b	40	11	3.4	5	
GTS A7.1	90	11	11.4	7	
GTS A?	50	11	3.5	6	
GTS A?	60	11	5	11	
GTS A?	80	11	6.2	10	
58 DCB					
GTS A 1.1	80	11	7.7	5	
GTS A 1.2	70	11	2.0	4	
GTS A 2.1	105	11	4.6	7	
GTS A 2.2	70	11	1.3	9	
GTS A 2.3	70	11	3.0	7	
GTS A 3.2	60	11	4.5	10	
GTS A 8.2	110	11	1.2	11	
GTS A10.1	90	11	6.0	8	
GTS A10.2	90	11	1.6	6	
GTS A12	100	11	8.0	7.5	BASALTIC INCL.
GTS A14.1	70	11	5.2	5	
GTS A14.2	60	11	8.0	8	BASALTIC INCL.
60 CTVC					
GTS A 1.1	100	11	7.8	6	
GTS A 1.2	70	11	16.0	2.3	
GTS A 3.1	100	11	6.6	4.5	
GTS A 3.2	60	11	9.0	5	
GTS A 4.2	90	11	5.4	5	
GTS A 4.3	50	11	3.8	4	
GTS A 5.1	70	11	5.4	5.5	
GTS A 6.1	90	11	28.0	23.0	HIGH VALUE
GTS A 6.7	90	50	5.0	10	
GTS A 8.1	90	50	5.5	10	VERY POROUS
GTS A 8.2	50	50	1.5	5	VERY POROUS

TAB. 11.8.9 CONTINUATION

SAMPLE NO.	LENGTH mm	RANGE kN	POINT-LOAD STRENGTH kN	PENETR. mm	REMARKS
61 GTVC					
CTS A 1.2	90	50	13.5	6	
GTS A 1.3	60	50	7.2	7	
GTS A 2	100	50	2.0	6	
GTS A 3	100	50	3.5	10.0	
CTS A 5.1	90	50	11	6.0	
GTS A 5.2	60	50	3.2	4	
GTS A 9.2	90	50	9.0	4	
GTS A10.2	100	50	12.0	4.5	
CTS A13.2	60	50	6.0	20.0	POROUS
65 GTVC					
GTS A 1.2	100	50	5.0	6	
GTS A 3.1	160	50	8.0	9	VERY POROUS
CTS A 3.2	90	50	2.5	15	
GTS A 4.2	70	50	3.0	3	
CTS A 4.3	60	50	3.8	3	
GTS A 4.4	60	50	3.5	3	
GTS A 8.2	70	50	2.8	8	
GTS A 9.2	40	50	2.0	7.5	
CTS A ?	90	50	1.2	5	
102 GTVB					
CTS A 1.1a	170	50	4.5	4	
CTS A 1.1b	170	50	8	2	
CTS A 1.2	90	50	1.5	7	
GTS A 3.1a	160	50	7	5	
CTS A 3.1b	160	50	5	4	
CTS A 3.2	100	50	4	7	
CTS A 4.1a	140	50	1.8	4	
GTS A 4.1b	140	50	3.3	5	
GTS A 4.2	130	50	3.2	6	
GTS A 6.1	90	50	5	8	
CTS A 6.2	90	50	4.8	4	
GTS A 8.1	70	50	5.3	5	
CTS A 8.2	70	50	5.3	3	
GTS A10.1	80	50	8	6	
CTS A10.2	100	50	6.5	17	
GTS A11.1	70	50	5	12	
CTS A11.2	50	50	7.8	6	
GTS A12.1	100	50	5.2	2	
GTS A12.2	50	50	1.2	6	fault

TAB. 11.8.9 CONTINUATION

SAMPLE NO.	LENGTH mm	RANCE kN	POINT-LOAD STRENGTH kN	PENETR. mm	REMARKS
169 GTVB					
GTS A 1.1a	150	50	9.8	10	
GTS A 1.1b	100	50	4.7	4	
GTS A 1.2	80	50	5.9	5	
GTS A 2	90	50	2.5	7	VERY POROUS
GTS A 3.1a	170	50	3.5	7	
GTS A 3.1b	100	50	12.0	5	
GTS A 3.2	110	50	13.0	7	
GTS A 4	200	50	8	6	
GTS A 4.1	100	50	4.5	6	
GTS A 4.2	100	50	7.8	7	
GTS A 5	240	50	9.3	5	
GTS A 5.1	130	50	3.0	3	POROUS
GTS A 5.2	110	50	9.5	6	POROUS
GTS A 6.1a	180	50	6.0	6	
GTS A 6.1b	100	50	5.2	4	
GTS A 6.2	110	50	0	15	VERY POROUS
GTS A 7.1	100	50	6.0	6	FAULT
GTS A 7.2	80	50	9.0	5	
GTS A 8.1a	140	50	9.3	6	
GTS A 8.1b	70	50	6.0	13	FAULT
GTS A 8.1c	70	50	11.2	9	FAULT
GTS A 8.2	60	50	3.2	13	SHREDDED
GTS A 9	270	50	8.2	4	
GTS A 9 a	140	50	4.7	10	
GTS A 9 b	110	50	2.0	6	
GTS A10.1a	220	50	13.3	8	
GTS A10.1b	110	50	7.7	6	
GTS A10.1c	100	50	9.2	3	
GTS A10.2	100	50	12.0	9	
GTS A11	300	50	10.4	9	
GTS A11 a	140	50	7.1	3	
GTS A11 b	120	50	5.8	8	
213 GTVC					
GTS A 6	80	50	4.2	12	
GTS A 7	160	50	2.5	3	
GTS A 7 a	90	50	3.1	4	
GTS A 8	230	50	7.2	15	POROUS
GTS A 8 a	90	50	1.5	8	
GTS A 9	170	50	0.5	15	SHREDDED
GTS A10.1	160	50	6.1	4	
GTS A10.1a	80	50	2.5	7	
GTS A10.2	90	50	1.8	17	SHREDDED
GTS A11.1	100	50	2.7	6	
GTS A11.2	70	50	4	17	
GTS A12	150	50	5.2	3	
GTS A13	70	50	0.5	15	SHREDDED
GTS A14	130	50	1	4	
GTS A15.1	150	50	3.7	3	
GTS A15.2	190	50	3	6	DIAM. NOT CONST.
GTS A16	130	50	4.2	5	
GTS A17	210	50	1	11	
GTS A17 a	120	50	2.8	2	

TAB. 11.8.9 CONTINUATION

SAMPLE NO.	LENGTH mm	RANGE kN	POINT LOAD STRENGTH kN	PENETR. mm	REMARKS
215 GTVC					
GTS A 5	240	50	7	2	
GTS A 5 a	80	50	4.8	2	
GTS A 5 b	140	50	6.9	4	
GTS A 5 c	90	50	0	20	VERY POROUS
GTS A 6	130	50	6.5	3	
GTS A 7	210	50	5	7	
GTS A 7 a	120	50	4.9	4	
GTS A 8	250	50	3	4	POROUS, WORM HOLES
GTS A 8 a	120	50	5	2	
GTS A 8 b	100	50	8	3	
228 GTVC					
GTS A 1.2	100	50	7	3	
GTS A 3	90	50	2	2	FAULT
GTS A 4	90	50	8	8	

11.9 Data Reduction and Processing

Since that time when electronical monitoring systems also conquered the oceanic research the amount of measuring data and information started to get more and more unbounded. For that reason most of the data reduction today is done by computers. The pre-processing onboard was carried out by the central computer system VAX-750 and by the transportable computer system PDP/LSI 11/23. Further data reduction and processing were carried out within the company's geophysical data center (VAX 780) and again with the PDP/LSI 11/23.

11.9.1 Multisonde Measurements

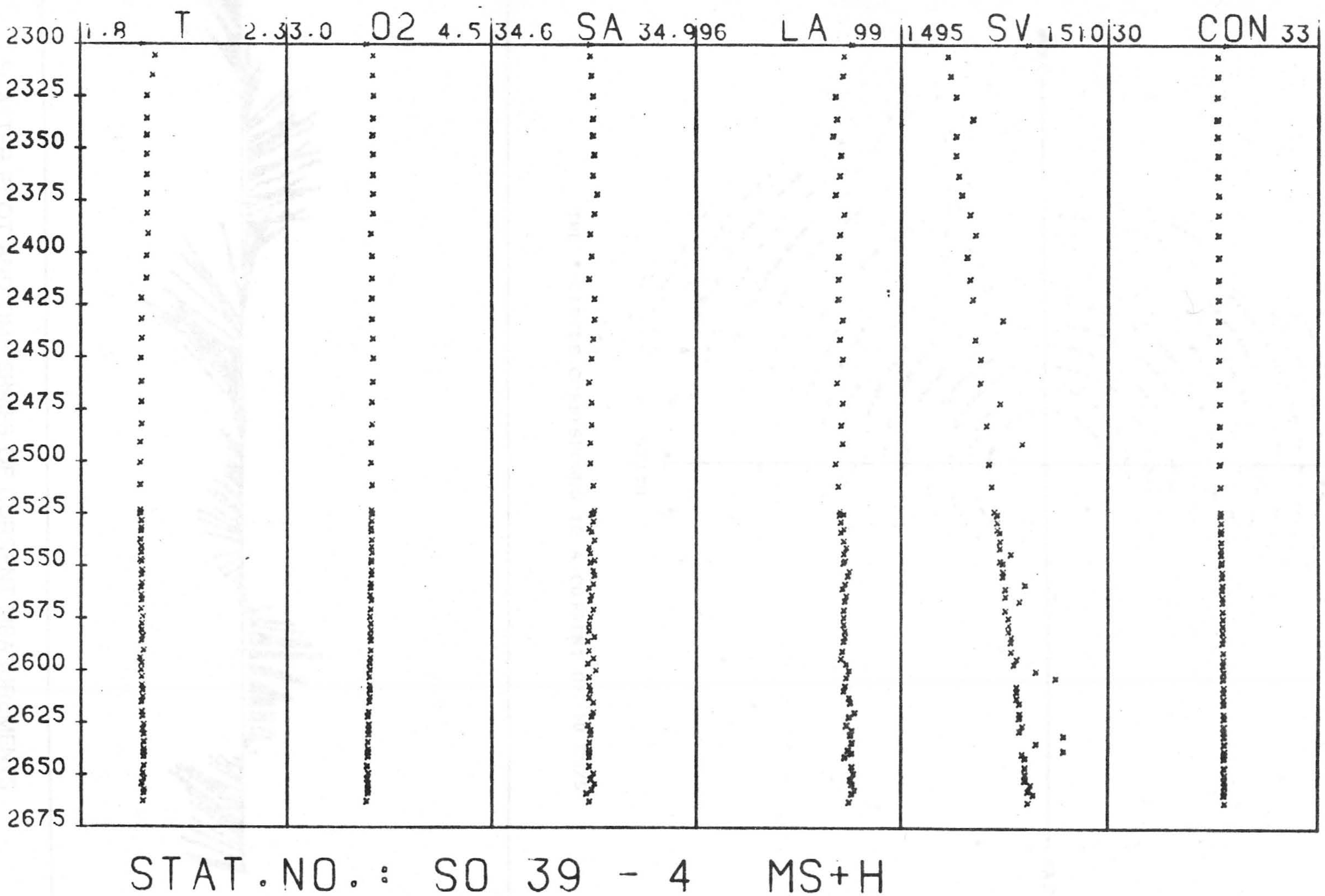
The STD-measurements carried out with the Multisonde were recorded either on the magnetic tapes of the PDP or on the permanent storage of the VAX. During profiling the data were on-line plotted on a graphic screen of the VAX-system. This provided the opportunity to have a quick-look control of measuring data and possible occurrences of hydrothermal anomalies. During GARIMAS 2 the main data control, reduction and preprocessing of STD-measurements was done on the VAX using the processing software which was already developed on the PDP. An example of the preprocessing is presented in Figure 11.9.1.

11.9.2 Current Measurements

The Aanderaa RCM 5 is a self-recording current meter. The current data are recorded on a 1/4 inch tape. After recovery of the instrument the tape is read with a special tape reader (Aanderaa Type 2650) and restored via a 24 V interface on the 1/2 inch magnetic tape of the PDP computer system. Similar to the Multisonde data reduction procedure the current data were preprocessed on board including

- convertion of the original readings into physical units;
- calibration, correction and reduction of the converted data;
- preparation of data listings;
- preparation of scatter plots and time series (Fig. 11.9.2).

FIG. 11.9.1 MULTISONDE ON-LINE RECORD



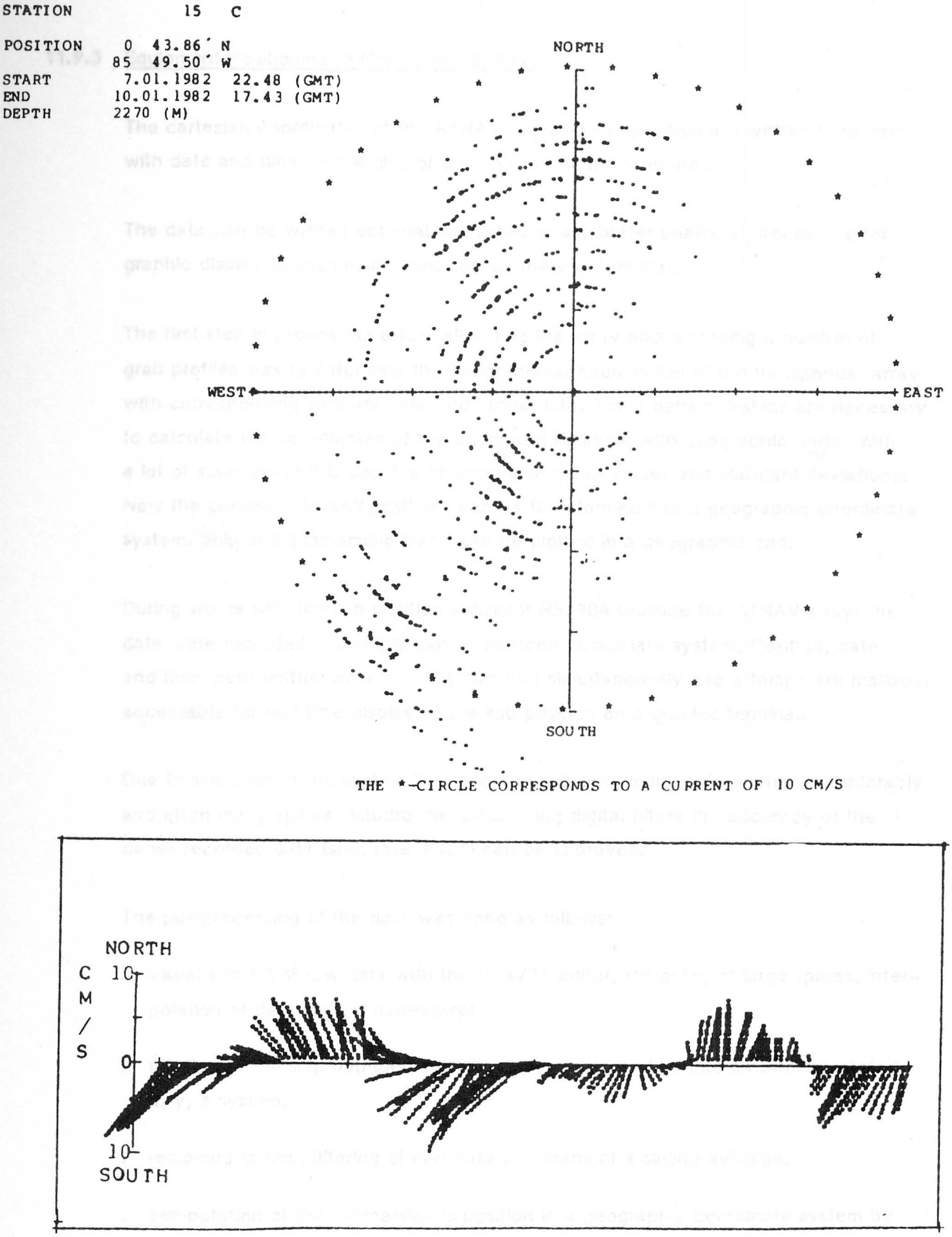


FIG. 11.9.2: SCATTER PLOT AND TIME SERIES OF CURRENT MEASUREMENTS

11.9.3 Equipment Positioning (ATNAV and RS/904)

The cartesian coordinates of the ATNAV ship and sub position are written together with date and time on the disc of the VAX/11 board computer.

The data can be written optional into a temporary buffer (mailbox), accessible for graphic display of submersible position on the vax terminal.

The first step in processing after calibrating the array and recording a number of grab profiles was to determine the geographical coordinates of the transponder array with corresponding GPS-fix data and range data. Three pairs of values are necessary to calculate the coordinates of the origin and its angle with geographic north. With a lot of such triples it is possible to determine mean values and standard deviations. Now the cartesian ATNAV positions can be transformed into a geographic coordinate system. Ship and submersible track can be plotted in a geographic grid.

During works with the sub position indicator RS/904 (outside the ATNAV array) the data were recorded in a ship's axis referenced coordinate system. Position, date and time were written on a VAX/11 disc and simultaneously into a temporary mailbox, accessable for real time display of the sub position on a graphic terminal.

Due to limitation of the system the recorded sub positioning data scatter considerably and often many spikes disturbe the data. Using digital filters the accuracy of the dense recorded data (shot rate 3 sec) can be improved.

The postprocessing of the data was done as follows:

- visual control of raw data with the VAX/11 editor, removing of large spikes, interpolation of data lack, if necessary;
- rotation of the ship bounded cartesian coordinate system into a north orientated x, y, z system;
- removing spikes, filtering of raw data by means of a sliding average,
- computation of the submersible's position in a geographic coordinate system by using the ship - sub distances and the geographic coordinates of the GPS (TRANSIT) navigated surface vessel.

Ship and submersible track now can be plotted in a geographic grid.

11.9.4 Visual Seafloor Monitoring

As already mentioned above the application of modern electronical systems also in the marine research led to a tremendous increase of data. This is especially true for the seafloor monitoring where the application of TV- and photo systems gave the opportunity to get detailed information about small scale seafloor features. The increasing data flood led to the recent decision to manage the observation data with the computer facilities already available on board of the vessel.
For this reason a software package was developed during GARIMAS 2 which gives the opportunity of following operations:

- quasi on-line recording of individual observations on computer data files;
- connection of observation and navigation data;
- separation of selected observations (for example all indications of sulfides)
- listing of selected observation in connection with observation time, position and water depth;
- mapping of selected observations on track-charts.

During the GARIMAS 2 cruise the management of seafloor observation data from TV-photo sledge tracks and TV-grab stations was as follows:

1. The on-line TV-observations directly were stored on computer data files.

2. These files were corrected later on reviewing the video tapes. Additionally the TV-sledge provided the opportunity to complete information by the interpretation of detail-photos which were processed directly on board of the ship.

3. Listings of the entire data files which already include the observation time and water depth were prepared and used for first steps of evaluation and as decision aid for further actions. An example is presented in Tab. 11.9.1.

4. The separation of selected observations gave the opportunity to focus on observations of special interest (see Tab. 11.9.2). Afterwards the corrected and completed observation data were combined with the corrected navigation data. On the base of this data set as a final step track charts marked with the different observations were prepared (Fig. 11.9.3).

TAB. 11.9.1: COMPUTER ADDED ON-LINE RECORD OF GEOLOGICAL OBSERVATIONS

STATION : SO 39-167 FSO
NAVIGATION SCHIFF: SAT GERAET: RS
28-SEP-85

13:32:03	2416	2377	TON
13:33:34	2419	2443	BOT1,BOP1,C,BL1-4
13:34:34	2412	2453	PI,S,C,ZERRUETTET
13:35:26	2414	2455	T,M2
13:35:44	2414	2450	D+,C,ANSTOSS,LOB
13:36:36	2412	2447	BOT,T,LOB
13:37:12	2433	2440	BOT,T,DS+
13:38:57	2416	2435	PI,M3,FE,C,BIOTURBATION
13:40:29	2420	2434	GC
13:41:50	2415	2437	GC,FB,C,HOLOTH.
13:42:29	2412	2436	G
13:42:54	2423	2434	PI,M3,FE
13:44:45	2485	2439	C,BL1,2,3
13:45:29	2411	2442	T,M3,PI
13:46:34	2412	2430	C,BL1-4
13:46:49	2415	2417	LOB
13:50:48	2408	2436	BOT,S,M3,C,BL1,2,3
13:53:07	2410	2435	M4
13:53:46	2414	2437	PI,M3
13:55:59	2405	2431	S,PI,M3,FE,C,BIOTURBATION
14:00:44	2436	2431	PI,S,M3
14:02:54	2487	2435	PI,M3,FE,FB,C,SPONGIE
14:03:54	2436	2436	TP,C,BL1-4
14:04:31	2435	2437	D-,T,D-
14:05:08	2485	2441	T,M1
14:06:29	2433	2456	PI,TP,C,D- CA 20M
14:07:47	2428	2463	T,M3
14:08:43	2430	2469	S,M3,FB
14:09:45	2424	2467	CS
14:10:21	2420	2470	GC,PI,PP,M3
14:11:02	2416	2470	PP,M3,FB,C,POLYPENSTOCK
14:11:20	2413	2470	G
14:12:30	2422	2470	PP,PI,M3
14:14:19	2410	2474	GC
14:17:59	2403	2495	PP,M3
14:18:53	2406	2495	PP,M2,++,FF
14:21:10	2412	2474	PP,M2,++
14:23:28	2409	2477	LOB
14:23:58	2409	2480	BOT,PP,M2
14:28:50	2410	2480	PP,M3
14:29:03	2411	2479	DS-,FB
14:29:57	2408	2482	PP,M2,GC
14:31:11	2484	2484	G,G,PP,M2
14:31:28	2423	2484	G
14:33:14	2484	2486	PP,SN,M2
14:33:30	2485	2486	G
14:34:24	2488	2487	PP,SL,M2
14:35:11	2485	2489	SL,M2
14:36:17	2490	2494	GC
14:36:29	2493	2495	G
14:37:05	2491	2498	PL,HP,HPC?,M1
14:37:30	2495	2498	G
14:38:41	2495	2490	PL,PP,M2
14:40:08	2490	2487	PP,PL,SN,M2
14:42:21	2493	2484	PP,PL,M1
14:44:11	2495	2486	--,PP,PL,M2
14:45:23	2492	2492	D+1
14:48:36	2502	2520	PL,PP,M2
14:51:00	2438	2517	C,BL1,2,3
14:51:51	2437	2518	GC,PP,M3

TAB. 11.9.1 CONTINUATION

14:56:47	2435	2527	DS+4,--
14:58:39	2417	2536	PP,PI,SN,M3
15:02:30	2404	2531	PP,PI,SN,M2
15:04:53	2437	2540	PP,PI,M2
15:06:03	2423	2538	SN,PP,FB
15:07:00	2414	2539	++
15:08:24	2427	2536	PP,PI,M2
15:10:57	2413	2526	T,M2,D+,LOB
15:12:53	2420	2520	BOT,PP,M1
15:17:27	2408	2497	PP,M1,HP,HFS
15:19:15	2408	2487	DS+,DS-,C,MAUER
15:20:22	2405	2486	PP,DS+,LOB
15:22:20	2412	2481	BOT,DS+,LOB
15:28:00	2436	2438	UP
15:28:31	2403	2438	TOP

$

TAB. 11.9.2: SELECTION OF HP-OBSERVATIONS FROM A GEOLOGICAL OBSERVATION RECORD

```
 STATION : SO 39-167 FSO
 NAVIGATION SCHIFF:  SAT GERAET: RS
 28-SEP-85

14:37:05      2491  2498 PL,HP,HFC?,M1
15:17:27      2408  2497 PP,M1,HP,HFS
$
```

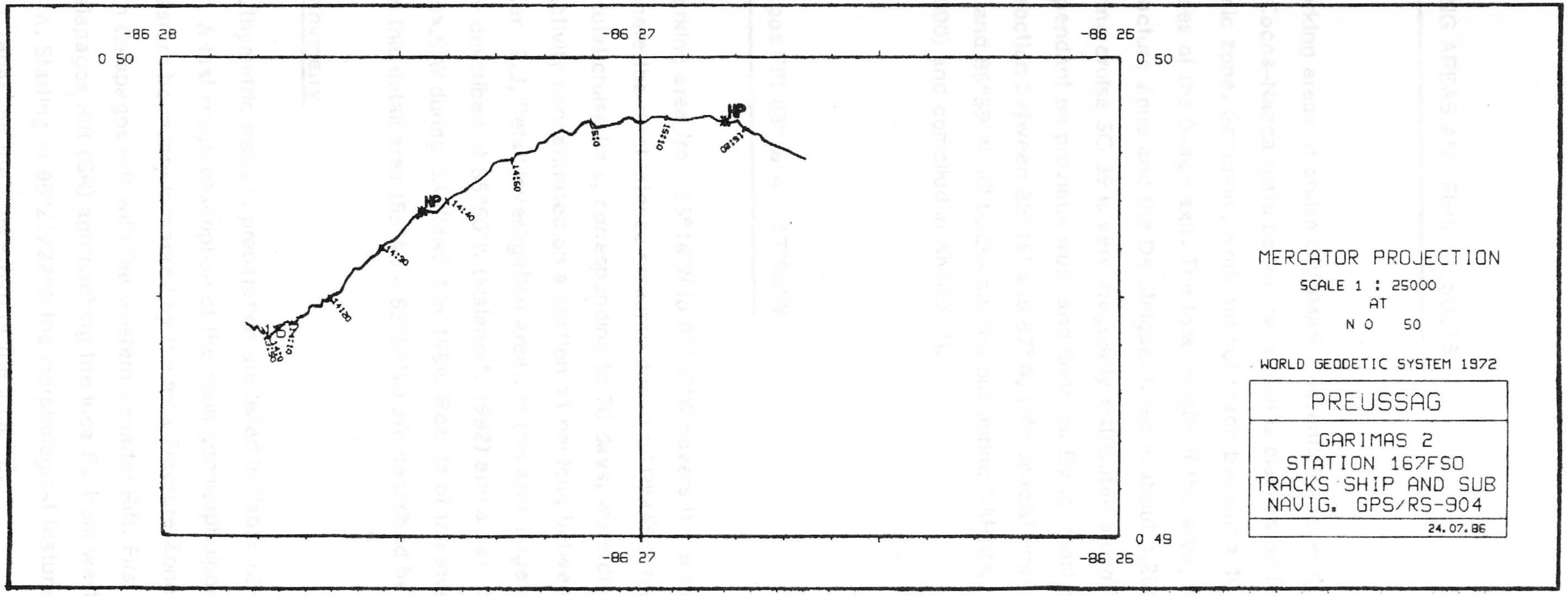


FIG. 11.9.3: OFOS TRACK COMBINED WITH SELECTED GEOLOGICAL OBSERVATIONS

12. WORKING AREAS AND FIRST RESULTS

The working areas of cruise GARIMAS 1 essentially cover that part of the Galapagos Rift or Cocos-Nazca plate boundary, which is claimed by Ecuador as an exclusive economic zone. Generally, work did not reach beyond a 10 nm wide swathe on both sides of the 0-age axis. The total length of this area, extending between the Inca Fracture Zone and the De Steiguer Deep is about 1,200 km. The work carried out during cruise SO 39 is very irregularly distributed along the entire length of the rift, dependant on previous work and findings. By far most of the operations centre in the section between 85°16' and 87°W, with special emphasis on the area between 85°54' and 85°59'W. All tracks carried out during GARIMAS 2 are mapped (scale 1:250.000) and compiled in ANNEX 3).

12.1 Galapagos Rift 85°16'W - 87°00'W

The working area from 85°16'W to 87°00'W covers those sections of the Galapagos Rift, where the most intense research during GARIMAS 2 took place. About 65 % of the total cruise time, corresponding to 70 days, were devoted to this area. The main activity concentrated on a section 11 nm long between 85°48' and 85°59'W (Chapter 12.3, Detail investigation area). In this area large massive sulfide occurrences are described at 85°50'W (Malahoff, 1982) and a new occurrence was detected at 85°54.5'W during GARIMAS 1 in 1984. Results of the investigations performed outside this detail area (85°48 - 85°59'W) are described below.

- Bathymetry

The bathymetric maps in preparation are listed in Table 12.1.1 and plotted in Fig. 12.1.1. A first rough description of the main geomorphological features:
The eastern boundary is marked by the Inca Fracture Zone, which connects the eastern Galapagos Rift with the western Ecuador Rift. First northward bendings of the Galapagos Rift (GR) approaching the Inca FZ from west can be recognized at 85°24'W. Starting at 85°21/22'W the morphological features clearly show a NNE-trend (8 deg), reflecting the fault strike of the Inca FZ.

The structural trend of the GR between the Inca FZ and 87°00'W can be subdivided into two major sections. From 85°21'W to 86°39'W the Galapagos spreading center is developed as an elevated ridge with a broad axial valley on top. The axial valley is characterized by a central high as axis of symmetry and parallel horst and graben structures on both sides. West of 86°39', up to 87°00'W the character of the accretion zone changes into a broad symmetric ridge with discontinuously occurring linear depressions at the northern and southern slopes.
The water depth of the accretion axis steadily decreases from 2,800 m at 86°24' to 2,200 m at 86°54'W.

Between 85°24'W and 85°32'W the Galapagos accretion axis is developed as an axial valley (AV) striking at about 100 deg.
The water depth of the axial valley floor varies between 2,750 and 2,800 m. The northern wall (NW) climbs up to 2,600 m, the southern wall (SW) up to 2,540 m. West of an axial volcano, rising up to 2600 m height at the base of the northern wall, the strike direction changes with a little bend to 98 deg. The AV depth decreases to 2,700 m, the well pronounced NW, exhibiting a steep inner slope, reaches 2,420 m height. Between 85°42' and 85°46'W the NW plunges and disappears. The AV seems to propagate into the NW and a tiny offset of the accretion axis of 0.5 nm to the south can be recognized at 85°46'W.

The western prolongation of the GR (85°46 - 85°57'W) is characterized by a pronounced AV at 2,550 - 2,660 m depth, striking 96 deg. The boundary walls climb up to 2,400 m (NW) and 2,460 m (SW). At 85°57'W the SW disappears, but is built up again after a small offset (0.5 nm) to the south at 85°58'W. The NW is not defined from 85°58.5' to 86°03.5'W, but is remarkably developed (up to 2,320 m depth) in the western continuation between 86°03.5' and 86°19'W. The SW disappears at 86°08.5'W and turns up discontinuously until 85°39' shaped as elongated ridge like segments of 2 to 5 nm length and 2,400 m height. The strike direction of the AV continues with 96 deg. until 86°21'W. Central axial highs mark the symmetry axis. At 86°21'W the accretion axis is dislocated 0.5 nm to the south. Between 86°21'W and 86°39'W the AV consists of a double rifted structure with pronounced axial highs and a linear NW, climbing up to 2,360 m.
At 86°39'W the character of the accretion axis changes. The chain of axial highs east of 86°39'W runs into a broad axial ridge, showing a strike direction of 93 deg. from 86°47' to 87°00'W. The axis of symmetry is marked by the highest elevations

of the ridge. Relict axial valleys of former spreading cycles are visible from 86°39'W to 86°55' at the southern slopes of th ridge and until 87°00'W at the northern slopes. The axial ridge climbs up to 2,200 m at 86°54'W.

The morpho-tectonic features observed in this segment of the GR fit into the volcano-genic-tectonic model of rift genesis developed during the GARIMAS 1 and GEOCYARISE projects: late rifting phase at 86°23/24'W (Fig. 12.1.3), main rifting phase at 85°57/58'W (Fig. 12.1.4), early rifting phase at 86°40'W, volcanic phase at 86°59'W (Fig. 12.1.5) and incipiant volcanic phase at 86°50'W.

. Rocks

Sampling of volcanites outside the detail investigation area (85°49 - 85°59'W) revealed no indications of high temperature hydrothermal alteration. 5 stations, 24 D, 30 GTVB, 48 D, 192 D and 196 GTVA (Fig. 12.1.2) recovered different types of ponded or pillow lava fragments, exhibiting either fresh appearance or low temperature seawater alteration.

. Sediments

8 box grab stations (14, 15, 22, 23, 44, 45, 71, 136 GK) were placed along this section of the Galapagos Rift at about 4.8 to 15 km north and south of the axis (Fig. 11.4.1, Chapter 11.4). Geochemical hints on recent or subrecent hydrothermal imprints based on board-analytical data cannot be recognized. At 71 GK (86°58.85'W) slightly enhanced Mn-concentrations (1.9 %) and a somewhat thicker oxidized surface layer (16 cm) was observed. Also 136 GK (86°30.50'W) showed higher Mn-concentrations at the surface (2.6 %) and from 0 - 13 cm (1.4 %). These enrichments may be traced back to normal diagenetic Mn-mobilizations from deeper strata.

. Seawater sampling and STD-measurements

7 stations were placed in this section (8, 9, 18, 19, 31, 62, 70 MS+H). No hints on recent hydrothermal activity were obtained from the temperature and turbidity data of the Multisonde probes. Some smaller Mn-anomalies are found, but have to be verified in detailed on-shore laboratory studies.

• Visual observations and hydrothermal indications

The optical mapping concentrated on the 86°23'W/86°30'W section of the Galapagos Rift, where 5 photo profiles (144, 145, 167, 197, 198 FSO) were placed. This area was chosen based on low temperature hydrothermal indications obtained during GARIMAS 1. The results of GARIMAS 2 did not prove the existence of high temperature activity. Additional low temperature indications were photographed:

144 FSO	17.42 - 17.56 h:	Talus fragments with silicatic impregnations; greenish sediment; white crabs, galathea
167 FSO	14.36 - 14.39 h: 14.42 + 14.45 h: 15.15 + 15.17 h:	Silicatic impregnations at pillow fragments; galathea galathea silicatic impregnations
197 FSO	23.22 - 23.25 h:	Silicatic impregnations at fresh pillow fragments; galathea
198 FSO	02.21 - 04.46 h:	Several indications: yellowish and greenish emanations at lava cushion margins; white crabs and mussel relicts; joint planes covered by smectites; black, granular deposits (possibly Mn-crusts) main activity: 3.21 - 3.27 h and 4.11 - 4.16 h

3 other photo-profiles were placed at 85°28' (111 FSO), 85°44'W (199 FSO) and 85°40'W (214 FSO). The photos obtained do not reveal any hydrothermal activity.

TAB. 12.1.1: BATHYMETRIC MAPS 85°16' - 87°00'W

	LONGITUDE/LATITUDE	SCALE	CONTOUR INTERVAL
1.	W 85°16' - 86°25' N 0°52' - 0°40'	1 : 50.000	20 m
2.	W 86°10' - 87°00' N 0°59' - 0°45'	1 : 50.000	20 m
3.	W 85°20' - 85°45' N 0°48' - 0°40'	1 : 20.000	10 m
4.	W 85°59' - 86°17' N 0°51' - 0°43'	1 : 20.000	10 m
5.	W 86°17' - 86°31' N 0°53' - 0°45'	1 : 20.000	10 m
6.	W 86°31' - 87°00' N 0°56' - 0°47'	1 : 20.000	10 m
7.	W 85°48' - 85°59' N 0°48' - 0°44'	1 : 10.000	5 m
8.	W 85°54' - 85°56' N 0°46.5' - 0°45.5'	1 : 5.000	5 m

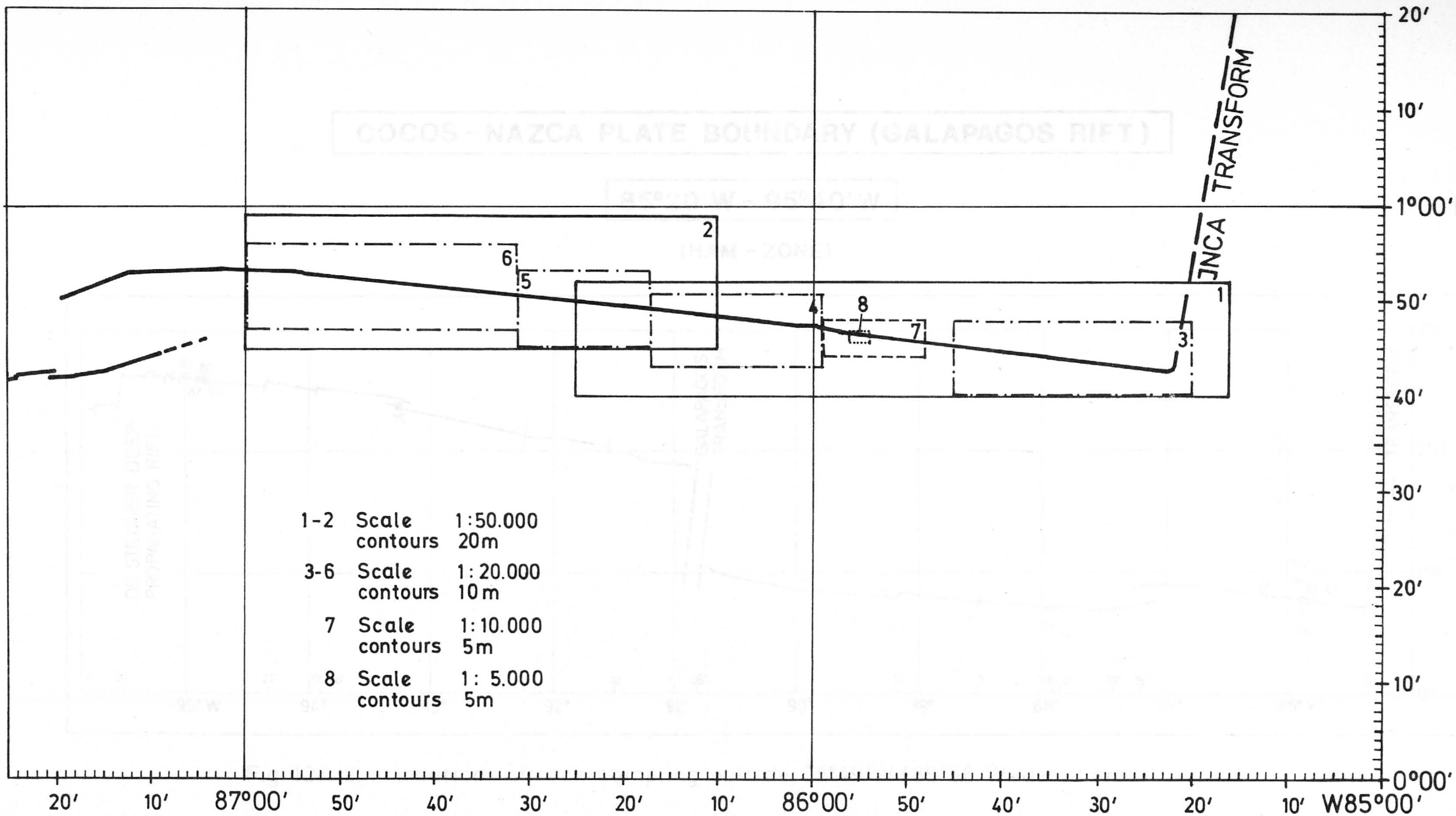


Fig. : 12.1.1. : SO-39 bathymetric maps: 85°16′-87°00′W

COCOS-NAZCA PLATE BOUNDARY (GALAPAGOS RIFT)

85°20'W - 95°40'W

(HAM-ZONE)

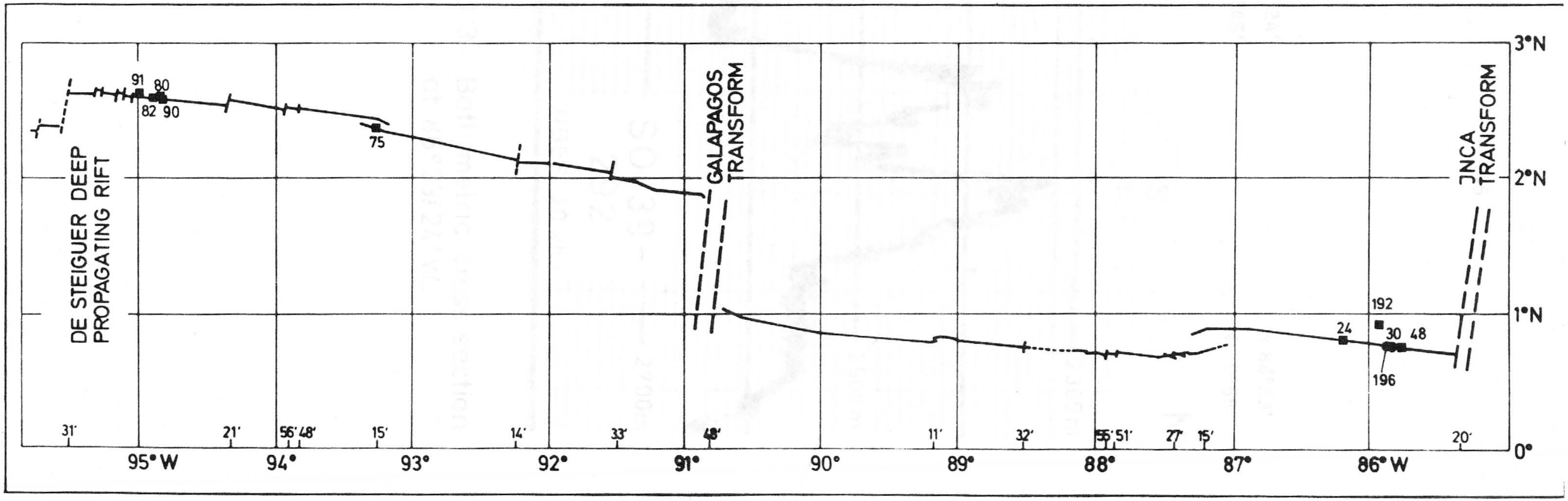


Fig. 12.1.2.: Locations of rock sampling outside 85°49'W/85°56'W-detail area.

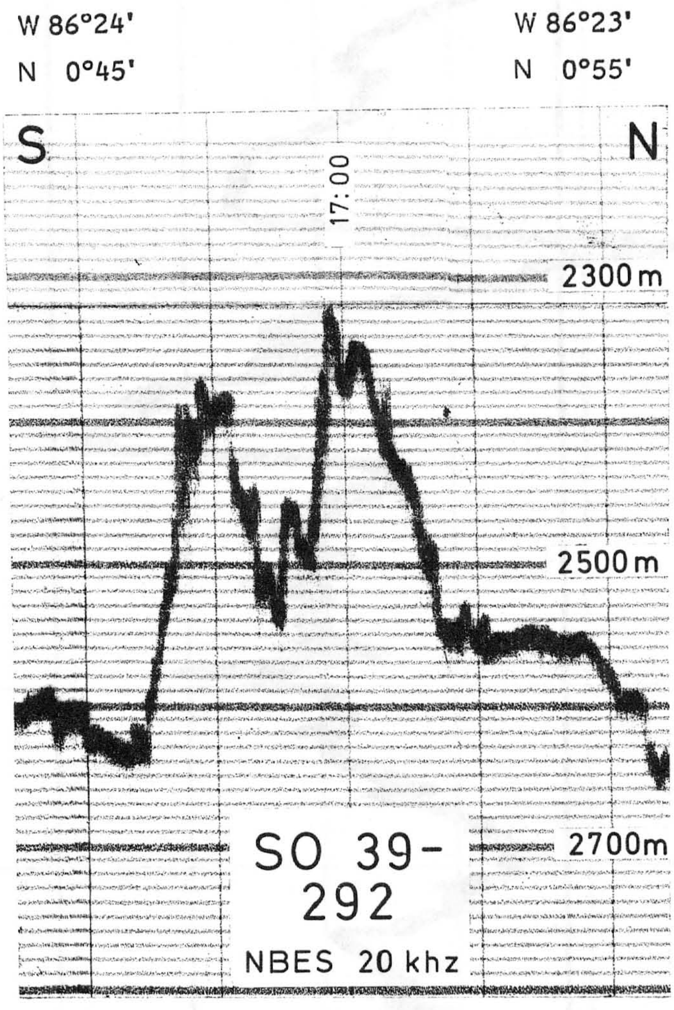


Fig. 12.1.3 : Bathymetric cross section at 86°23/24'W.

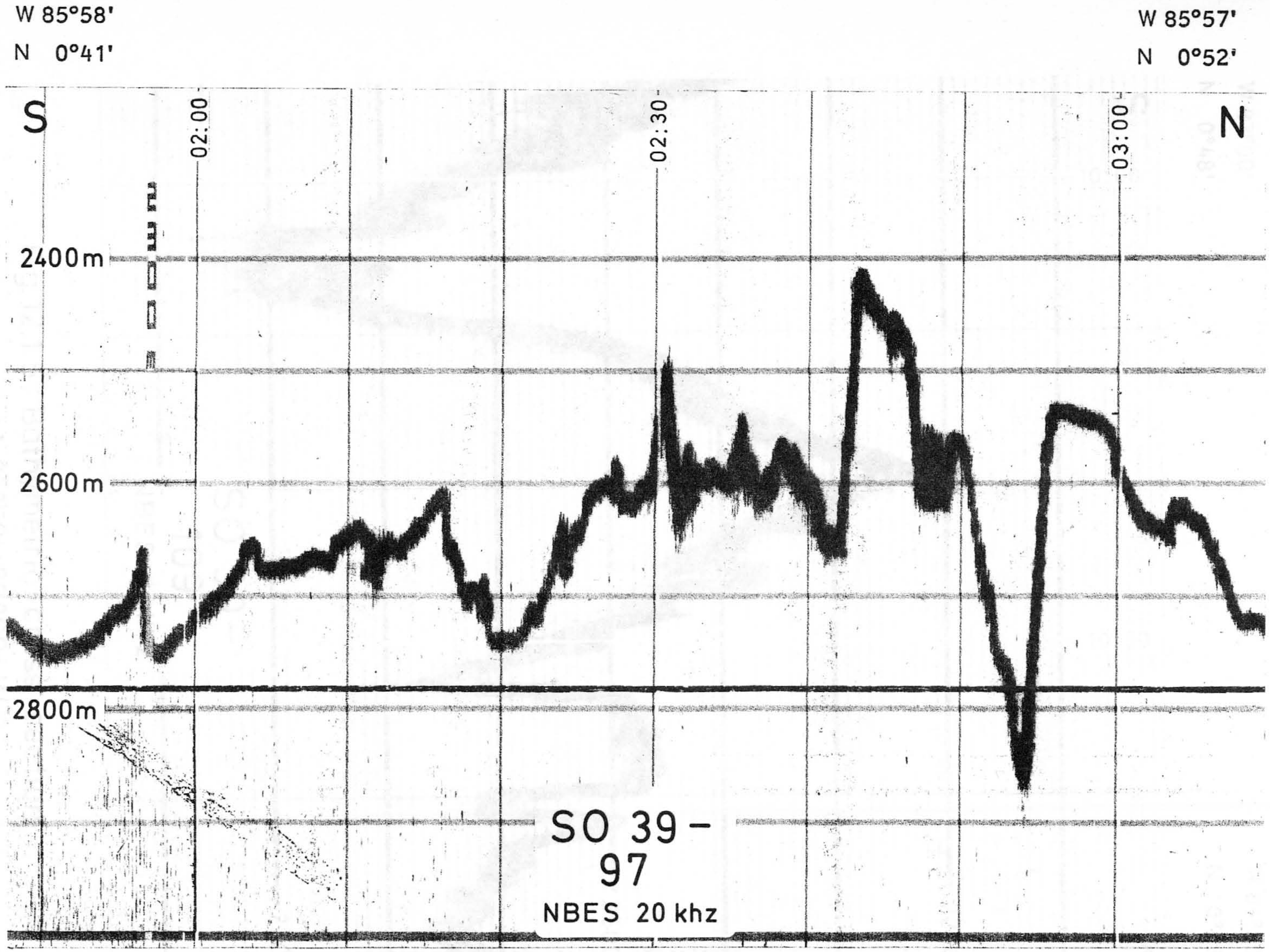


Fig. 12.1.4 : Bathymetric cross section
at 85°57/58'W.

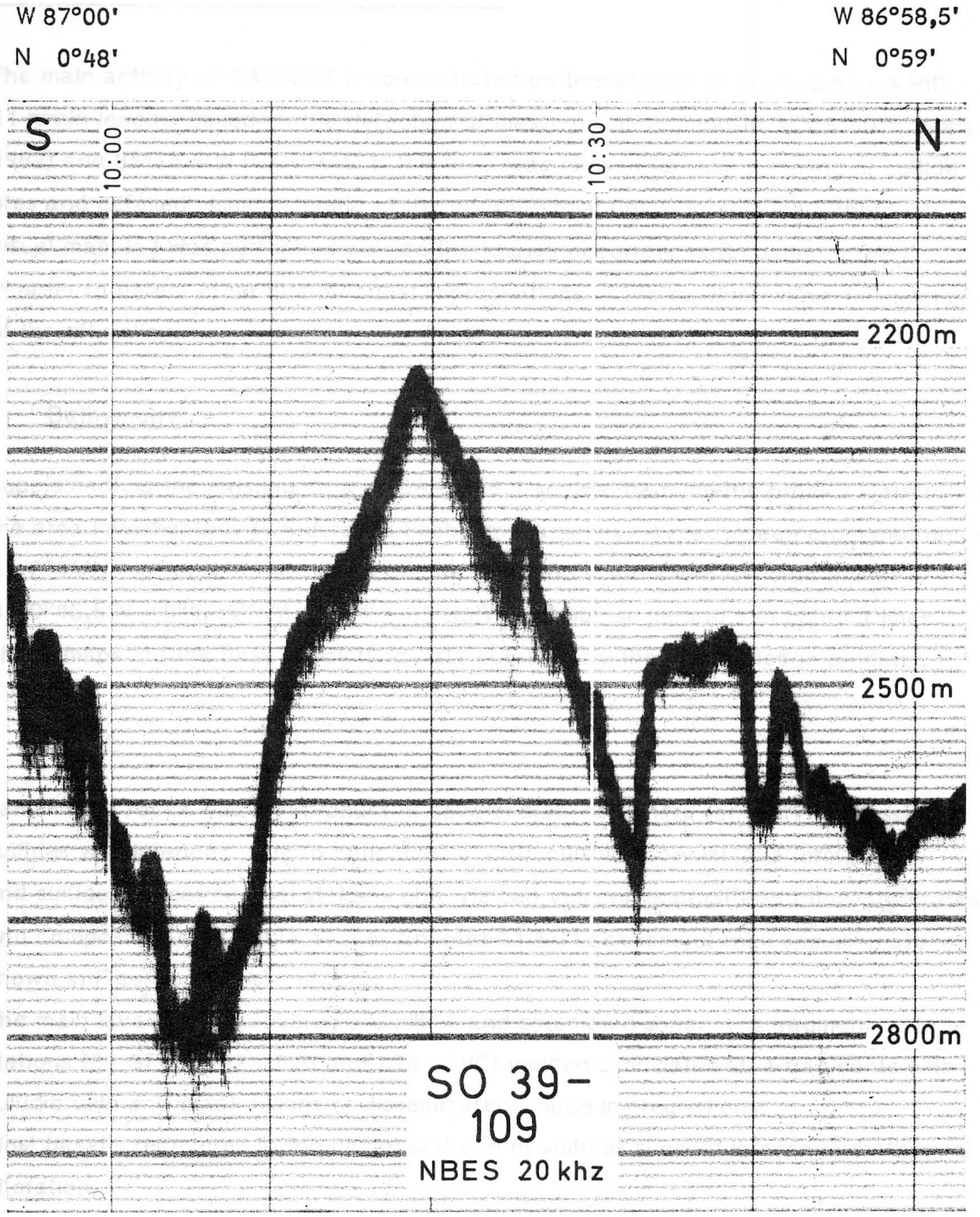


Fig. 12.1.5 : Bathymetric cross section
at 86°59'/87°00' W.

12.2 Detail Investigation Area 85°48'W - 85°59'W

The main activity of GARIMAS 2 concentrated on this section of the Galapagos Rift, 11 nm in length. Based on the detection of massive sulfide deposits at 85°50'W (Malahoff, 1982) and 85°54.5'W (GARIMAS 1) this area was chosen for bulk sampling of sulfide ores and detailed visual mapping of the hydrothermal fields. In addition a thorough visual mapping was performed outside the known occurrences (Locations A, B1) in order to detect other hydrothermal impregnations of the seafloor within this section of the rift valley.

. Bathymetry

Supplementing the existing data of GARIMAS 1 several bathymetric profiles were run in the area investigated. Two detailed Seabeam maps have already been produced on-board:
A. 0°44'N - 0°48'N/85°48'W - 85°59'W; 1:10.000 scale and 5 m contour lines
B. 0°45.5'N - 0°46.5'N/85°54'W - 85°56'W; 1:5.000 scale and 5 m contour lines.
These maps are the base for plotting data obtained by the photo-sledge program.

. Rocks

Sampling of rocks was a byproduct of several stations, where recovery of massive sulfides was intended. Due to difficulties in distinguishing special lava formations and sulfide edifices several stations only yielded volcanites of different flow structures and composition (see Table 11.5.5, Chapter 11.5). Locations of rock sampling are shown in Figures 12.2.4 - 12.2.6).
The main lava types recovered are pillow and scrambled sheet lava fragments. Three stations (34 GTVB, 102 GTVB and 226 GTVC) yielded brecciated lava fragments with sulfidic vein and crack fillings or disseminated sulfide impregnations.
Most basalts recovered in the neighbourhood of sulfides showed intense hydrothermal alteration.

. Sediments

A special sampling program to evaluate the impact of hydrothermal emanations on the geochemistry of surrounding sediments was not performed in this area. Sediments recovered in TV-grab hauls were sampled and forwarded to several universities (Aachen, Hamburg, Braunschweig).

. Seawater sampling and STD-measurements

While the measurement of temperature and turbidity at 6 stations along the rift axis (2, 4, 13, 49, 54, 175 MS+H) showed no anomalous data in the deep water structure above the seafloor, at 49 MS+H (0°45.17'N, 85°48.06'W) Mn-anomalies, both in dissolved and particulate matter were observed from 2,665 to 2,520 m depth (see Location K, Fig. 12.2.1).

. Visual seafloor mapping (OFOS) and hydrothermal indications

28 photo profiles were run in this section. The total length of profiles amounts to 39 nm. The main area investigated extents from 85°53' to 85°56'W and covers the massive sulfide occurrence at Location B1 (85°54.5 - 85°55'W) and its eastern and western prolongation. (Fig. 12.2.9, 12.2.10.) The results obtained demonstrate that the sulfide occurrences cover an area of 650 m length and about 100 m width. Individual outcrops were observed outside of this area. The occurrence of sulfides at Location B1 is connected to distinct tectonic lineaments, striking mostly parallel to the rift axis resp. marginal faults of the rift valley. A correlation of certain lava types of low viscosity and hydrothermal sites seems to exist but has to be verified by detailed evaluation of the photo-profiles. Massive sulfide outcrops at Location B1 are associated in part with larger Fe/Mn-oxid-stacks of primary low-temperature origin. In addition also silicatic edifices were observed, showing similar shapes and sizes as sulfide outcrops.

In addition to the detailed photoprofiling at Location B1 profiles were placed at Location A (85°50'W, Fig. 12.2.7) in order to supplement data gathered during GARIMAS 1. The photo-profiles located outside of detail areas A and B1 resulted in the detection of 8 new hydrothermal fields (B2, C-J; see Fig. 12.2.1 and Tab. 12.2.1). Locations E and F consist of sulfide stacks, slightly oxidized at surface. At location E these stacks are located within a talus slope, at location F they are rooted at the boundary of fresh nodular sheet lava and old pillow lava terrain.

The high diversity of products occurring at hydrothermal sites was proven by the detection of amorphous silica chimneys at Locations C, D, G and hydrothermal mound assemblages (Locations B2, H, J) consisting of silicatic/silica and/or Fe-Mn-oxide mineralizations, mostly building up edifices of layered or crust-like structures. While Locations C and D have been found at the base of the axial valley bordering northern fault scarp, the new sites E, G, H and J seem to be located on a lineament striking 95° in prolongation of the B1 occurrence. Only site F is situated at the slope of an axial volcanic cone. Tab. 12.2.1, Fig. 12.2.1 and Figs. 12.2.7 - 12.2.12 inform about details on hydrothermal features observed and locations of photo-sledge tracks.

. Sulfide sampling

The results obtained are more than satisfying in respect to the amount recovered. In total 19.9 t of massive sulfide ores were sampled during GARIMAS 2:

875 kg at Location A (43 GTVB, 61 GTVC; Fig. 12.2.2)

17.545 kg at Location B1 (Fig. 12.2.3)

1480 kg at Location F (228 GTVC; Fig. 12.2.2).

The largest sulfide block was sampled at station 126 GTVC: 3347 kg with a pyramidal shape of 180 x 145 x 125 max. size. But in point of view of a coherent sulfide deposit at surface the results are somewhat disappointing. Photo-sledge profiles as well as TV-grab sampling attempts proved the existence of only discontinuous sulfide outcrops within the hydrothermal fields investigated. In addition silicate- and Fe/Mn-oxide stacks are occurring within and around sulfide sites.

While BAC- and CSC-data where gathered on fragments or small drill cores of larger blocks the MF- data represent an average of the total material recovered.

The results obtained prove the high regional variability of Cu- and Zn-concentrations at Location B1. Zn varies between 0.20 and 32.2 %, but concentrates in the range of 0.5 to 3 %. Cu shows less extreme variations (1.10 - 11.20 %).

Histograms of Cu-, Fe- and Zn-variations in massive sulfides are given in Fig. 12.2.13.

Results of on-board analyses of non-sulfidic hydrothermal products (silica stacks, Fe-Mn-crusts) are attached in Tab. 12.2.3.

TAB. 12.2.1: NEW INDICATIONS OF HYDROTHERMAL ACTIVITY AND PRODUCTS IN THE GALAPAGOS RIFT VALLEY BETWEEN 85°48' AND 85°59'W

	STATION	TIME (GMT)	HYDROTHERMAL INDICATIONS
1.	Location B2		
	148 FSO	20.49 - 20.56	HP: m-high edifices of greyish, sinter-shaped material with yellowish mottles (Fe-silicates or silica?); at base brownish sediments
	148 FSO	21.01 - 21.02	HP: as above
	187 FSO	04.14 - 04.16	HP: as above
2.	Location C		
	110 FSO	05.03 - 05.08	HP: greenish to yellowish silica-stacks, sinter-like habitus; dm- to m-height
		05.11, 05.12, 05.13	HP: as above
	123 FSO	15.25 - 15.26	HP: as above
		17.16 - 17.30	HP: as above
		17.36 - 17.52	HP: as above
		17.57 - 17.58	HP: as above
		18.54 - 18.57	HP: as above
		19.03 - 19.04	HP: as above
		silica stacks sampled at station 124 GTVC.	
3.	Location D		
	186 FSO	19.55	HP: silica-chimneys with greyish crust; partly yellowish surface
		22.49	HP: small yellowish chimneys of dm-size
		23.06 - 23.08	HP: between and on lava cushions (pillows), crusts and small stacks of grey silica or silicatic precipitates
	182 FSO	19.39 - 19.41	HP: as above

TAB. 12.2.1 CONTINUED

	STATION	TIME (GMT)	HYDROTHERMAL INDICATIONS
4.	Location E		
	194 FSO	03.00 - 03.01	HH?, HP: grey, nodular precipitates on talus; stacks of sulfides (?) at base of talus-slope; dark sediment coloration
		03.08 - 03.10	HH?, HP: as above
	217 FSO	21.52 - 21.57	HP: grey, mostly flat, sinter-like mineralizations on talus fragments
		22.05	HP: as above
		22.18 - 22.19	HP: as above
5.	Location F		
	225 FSO	16.59	HH: sulfide edifices of several meters height; at the boundary of old (PL) and fresh (SN, Pi) lava flows; sediment cover in PL-terrain 70 %, in SN/Pi areas 5 %; no oxidation rims at sulfide edifices; massive sulfides sampled during station 228 GTVC
6.	Location G		
	225 FSO	19.03	HP: several small (- 1 m) stacks and chimneys of silica mineralizations; surface of edifices mostly grey, partly yellowish grey; structure layered and crust-like; PP/Pi-terrain; 50 % sediment
7.	Location H		
	225 FSO	19.18 - 19.21	HP, HM: crust-like edifices (silicates?); mainly grey, partly yellowish-brown and black; no stack structures
8.	Location J		
	190 FSO	19.47 - 19.48	HP: several small silica chimneys in a fissured pillow lava terrain covered by 30 % sediment
9.	Location K		
	49 MS+H	0°45.17N/85°48.06'W	Mn-anomalies in seawater from 2,665-2,520 m depth

TAB. 12.2.2: CHEMISTRY OF MASSIVE SULFIDES, LOCATION B (ON-BOARD ANALYSES)

STATION	MATERIAL	SAMPLE	CU %	ZN %	CO ppm	PB ppm	FE %	S %	SiO_2 %	MO ppm	AS ppm	SE ppm
50 GTVC	Sulfide	BAC M1	1.9	33.5	< 30	187	8.9	23.8	24.1	200	< 50	< 20
58 DCB	Sulfide	BAC M2	0.25	2.9	40	795	29.9	34.1	27.8	140	140	< 20
60 GTVC	Sulfide	BAC M3	3.4	1.5	56	156	36.1	45.2	10.9	60	< 50	< 20
61 GTVC	Sulfide Loc. B	BAC M4	6.8	0.07	304	58	27.6	29.0	32.0	360	100	130
65 GTVC	Sulfide	BAC M5	7.4	1.2	257	180	35.9	44.0	3.9	110	130	160
102 GTVB	Sulfide	BAC M6	8.7	1.5	68	85	30.0	34.5	18.8	220	100	40
102 GTVB	Sulfide drill cores	BAC M7	11.1	1.7	124	107	20.6	24.1	37.0	180	< 50	40
106 GTVB	Sulfide	BAC M8	0.14	4.6	< 30	568	13.3	19.2	55.4	< 20	< 50	< 20
112 GTVB	Sulfide drill cores	BAC M9	6.3	0.45	100	120	24.9	26.0	35.6	180	50	40
112 GTVB	Sulfide	BAC M10	6.8	0.15	250	40	30.4	33.0	22.8	250	110	60
117 GTVB	Sulfide	BAC M11	1.7	1.2	40	520	18.5	21.0	50.7	120	70	< 20
120 GTVA	Sulfide	BAC M12	0.39	0.24	< 40	130	27.7	20.6	40.3	90	70	< 20
121 GTVA	Sulfide	BAC M13	2.0	12.1	< 40	500	28.1	32.4	16.8	140	80	< 20
126 GTVC	Sulfide	BAC M14	2.1	0.05	130	120	34.2	32.3	21.9	310	160	50
127 GTVC	Sulfide	BAC M15	20.3	0.03	360	50	30.9	35.7	1.4	180	70	400
146 GTVC	Sulfide	BAC M16	19.6	1.9	110	100	22.2	24.0	25.9	260	< 50	40

Analysts: K. Becker, P. Herzig (RWTH Aachen)

TAB. 12.2.3: CHEMISTRY OF NON-SULFIDIC HYDROTHERMAL PRODUCTS (ON-BOARD ANALYSES)

STATION	LOCATION	MATERIAL	SAMPLE	MN %	FE %	CAO %	SIO_2 %	MO ppm	PB ppm	AS ppm	SE ppm	CO ppm	NI ppm
124 GTVC	C	silica stack	BAC 30	9.2	12.7	0.8	69.3	120	< 50	< 50	< 20	< 40	30
125 GTVC	D	Mn-crust	BAC 31	38.3	0.51	3.1	0.7	650	< 50	< 50	< 20	< 40	130
120 GTVA	B	amorphous silica	BAC M12a	.01	5.0	<0.1	>90	<20	< 50	< 50	< 20	< 40	<30
134 GTVC	B	Mn-crust	BAC 33	39.0	0.23	2.6	0.4	1300	< 50	< 50	< 20	- 40	90
134 GTVC	B	Mn-Fe-oxihydroxide	BAC 34	31.4	12.0	2.7	9.8	1000	< 50	< 50	< 20	- 40	50
135 GTVC	B	Mn-crust	BAC 35	39.0	0.25	3.9	0.6	1400	< 50	< 50	< 20	< 40	160
124 GTVC	C	silica stack	BAC 30a	0.02	1.8	<0.1	-90	<20	< 50	< 50	< 20	< 40	<30

Analysts: K. Becker / P. Herzig (RWTH Aachen)

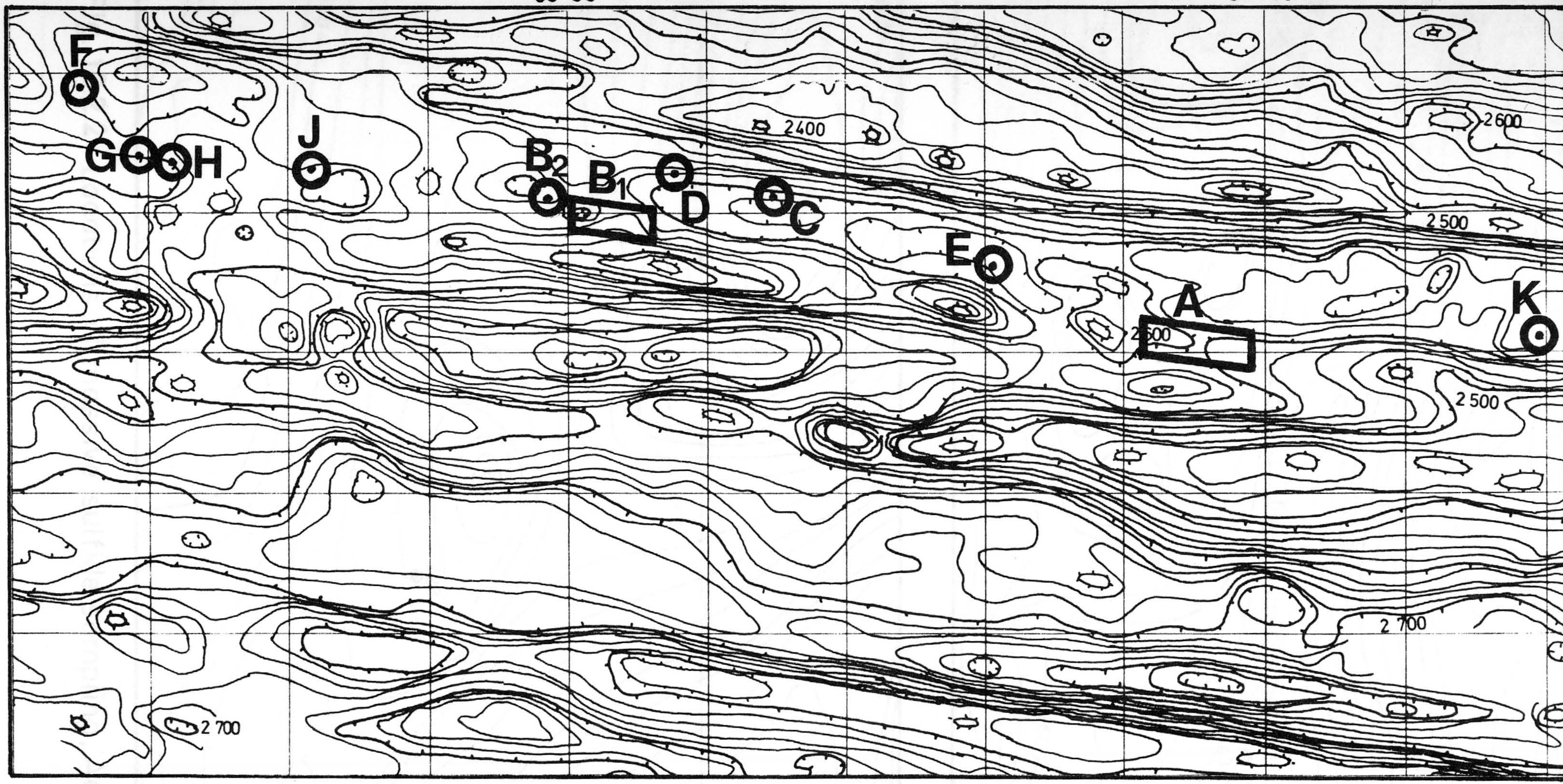


Fig. 12.2.1. : Hydrothermal products and indications: 85° 48'–85°59'W, Galapagos Rift Valley.

new indications Garimas 2 known occurences

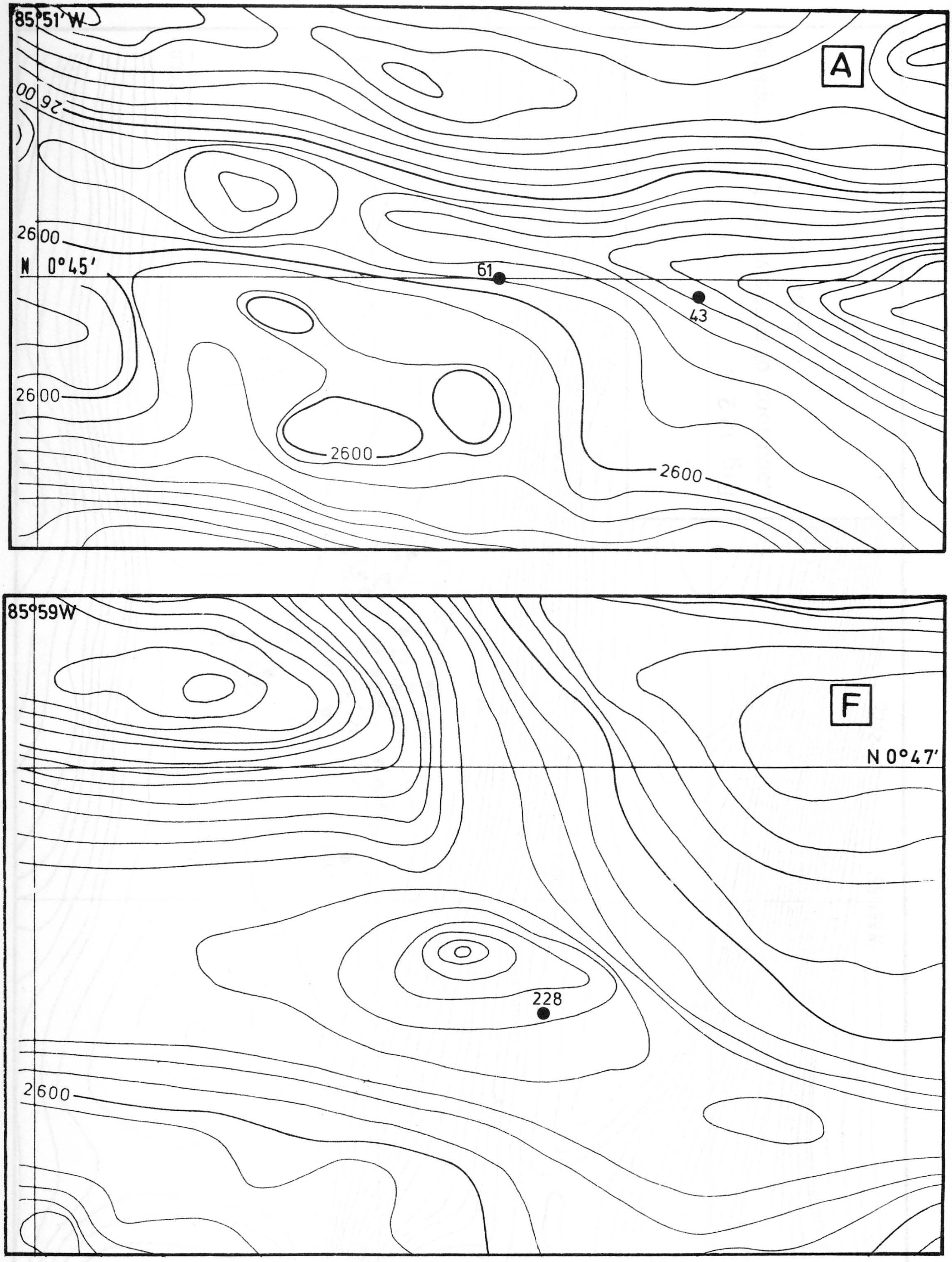


Fig. 12.2.2: Locations of massive sulfide sampling, Areas A and F.

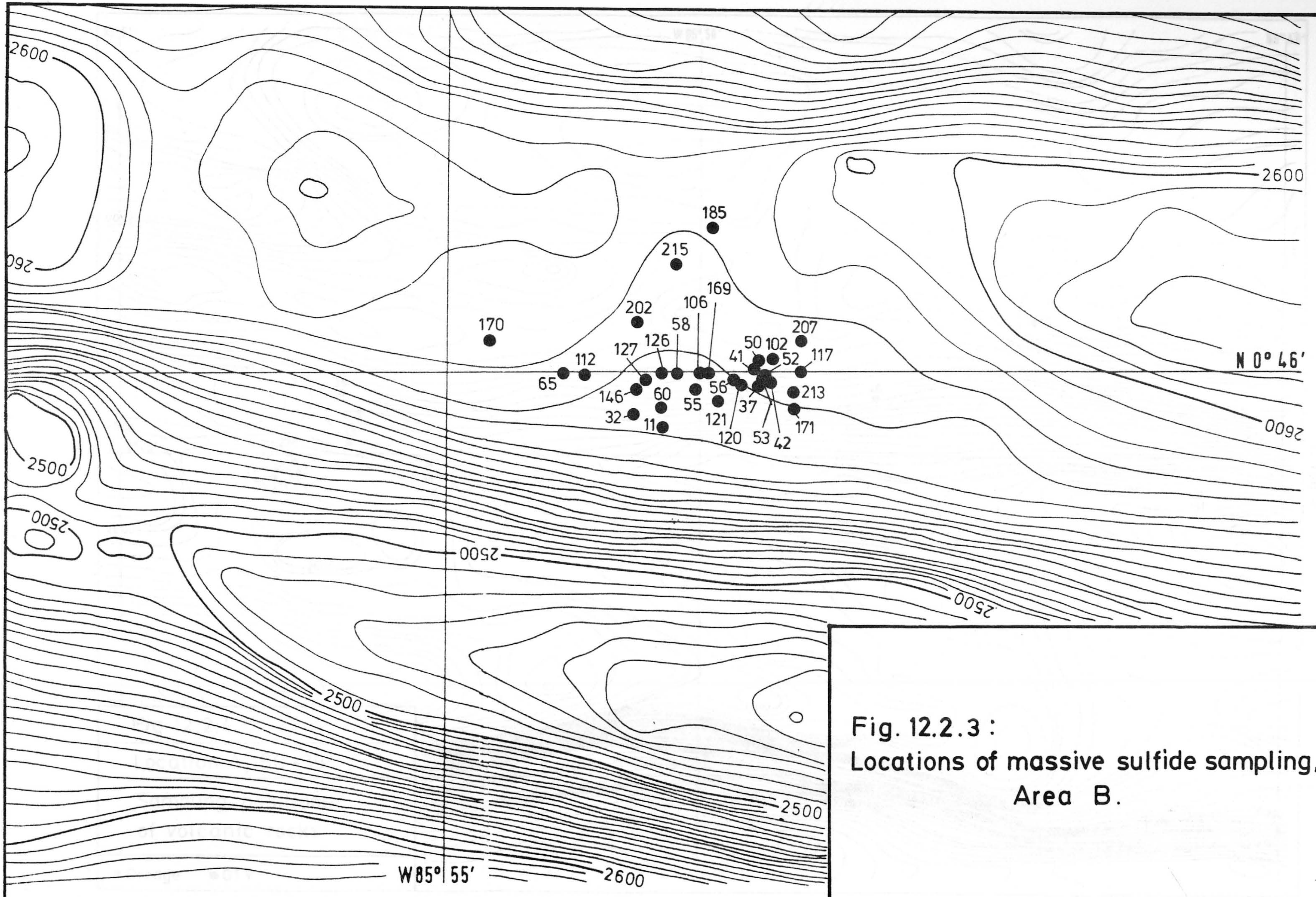


Fig. 12.2.3 :
Locations of massive sulfide sampling, Area B.

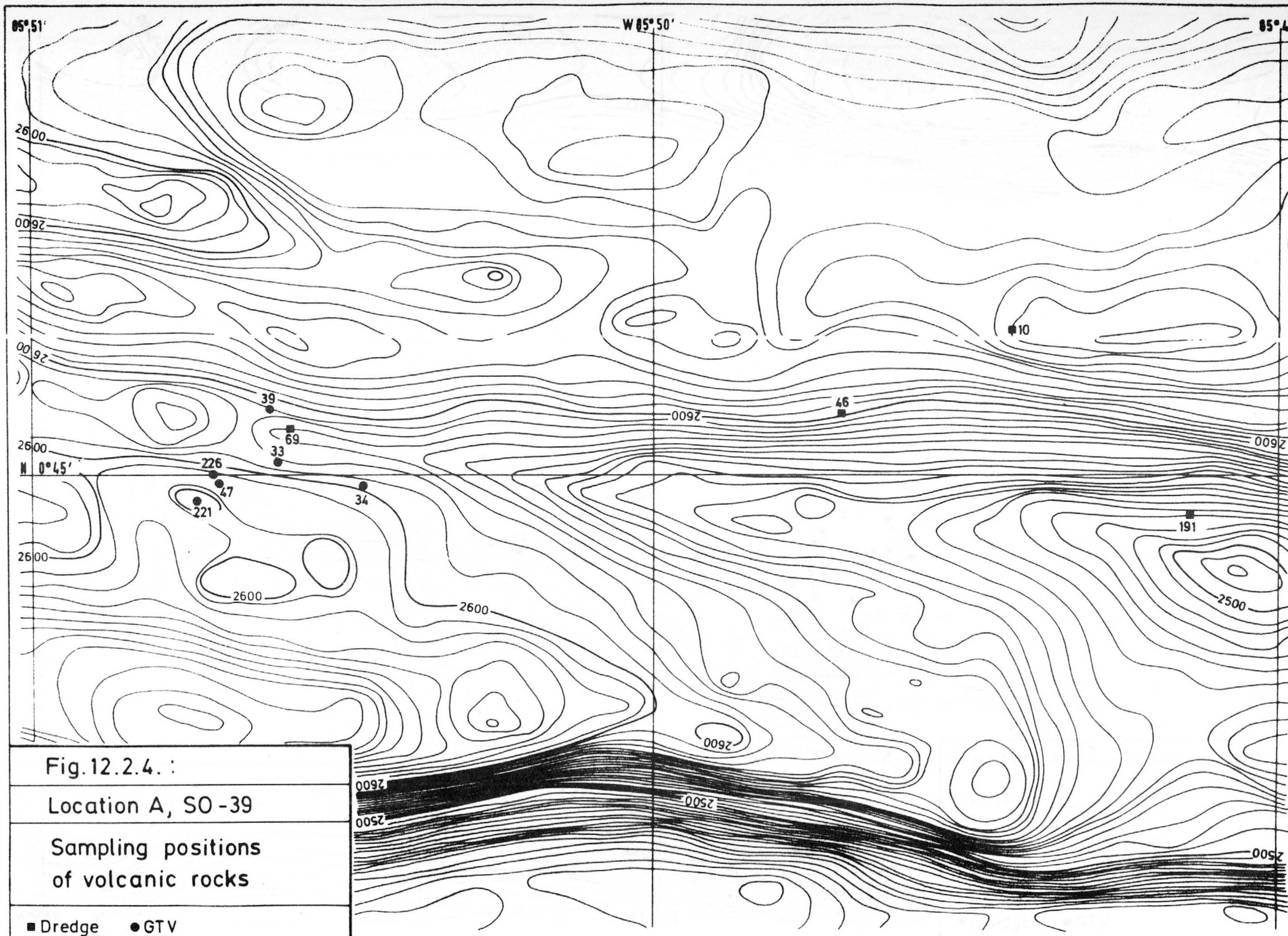


Fig. 12.2.4. :

Location A, SO -39

Sampling positions of volcanic rocks

■ Dredge ● GTV

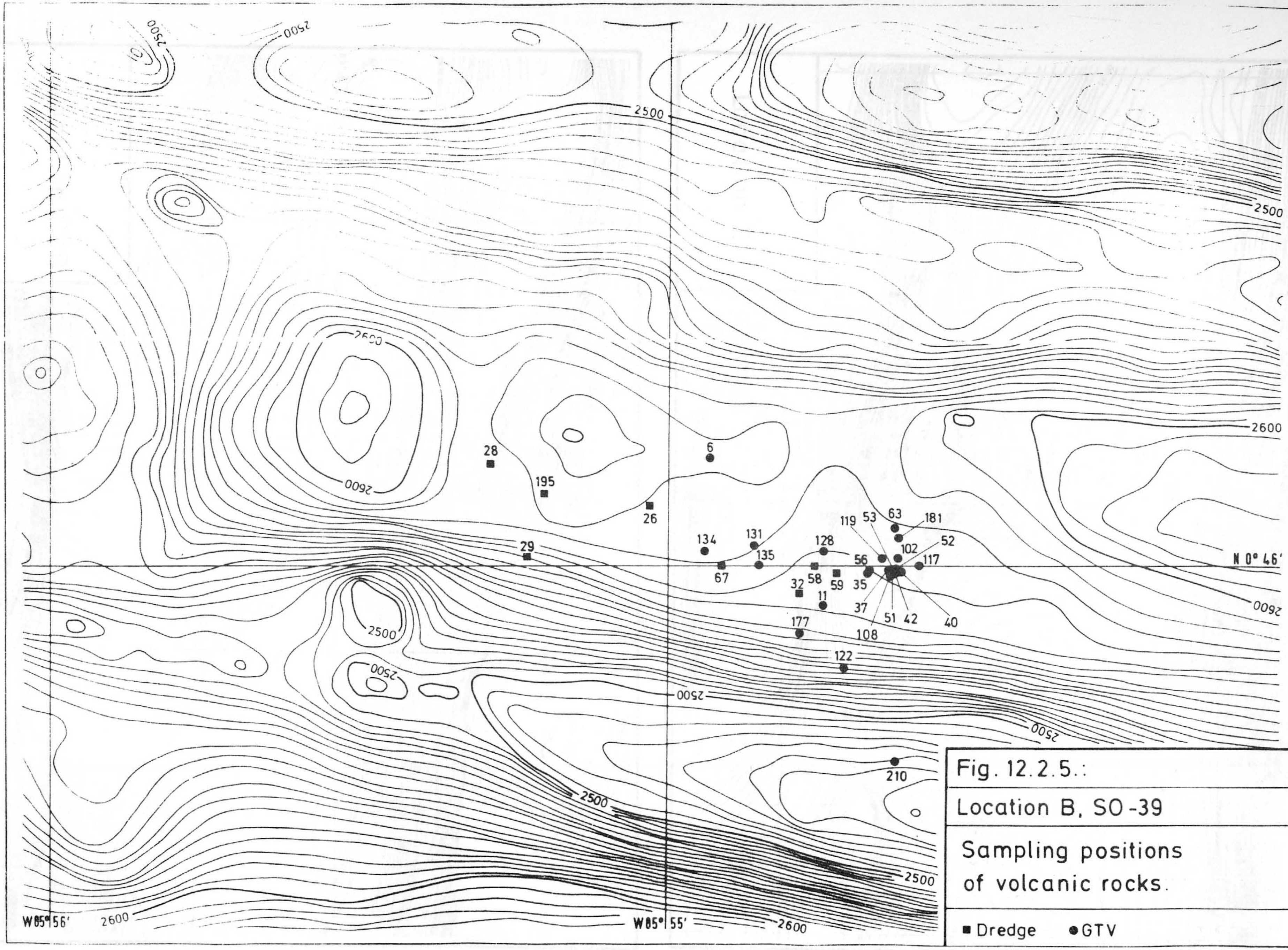
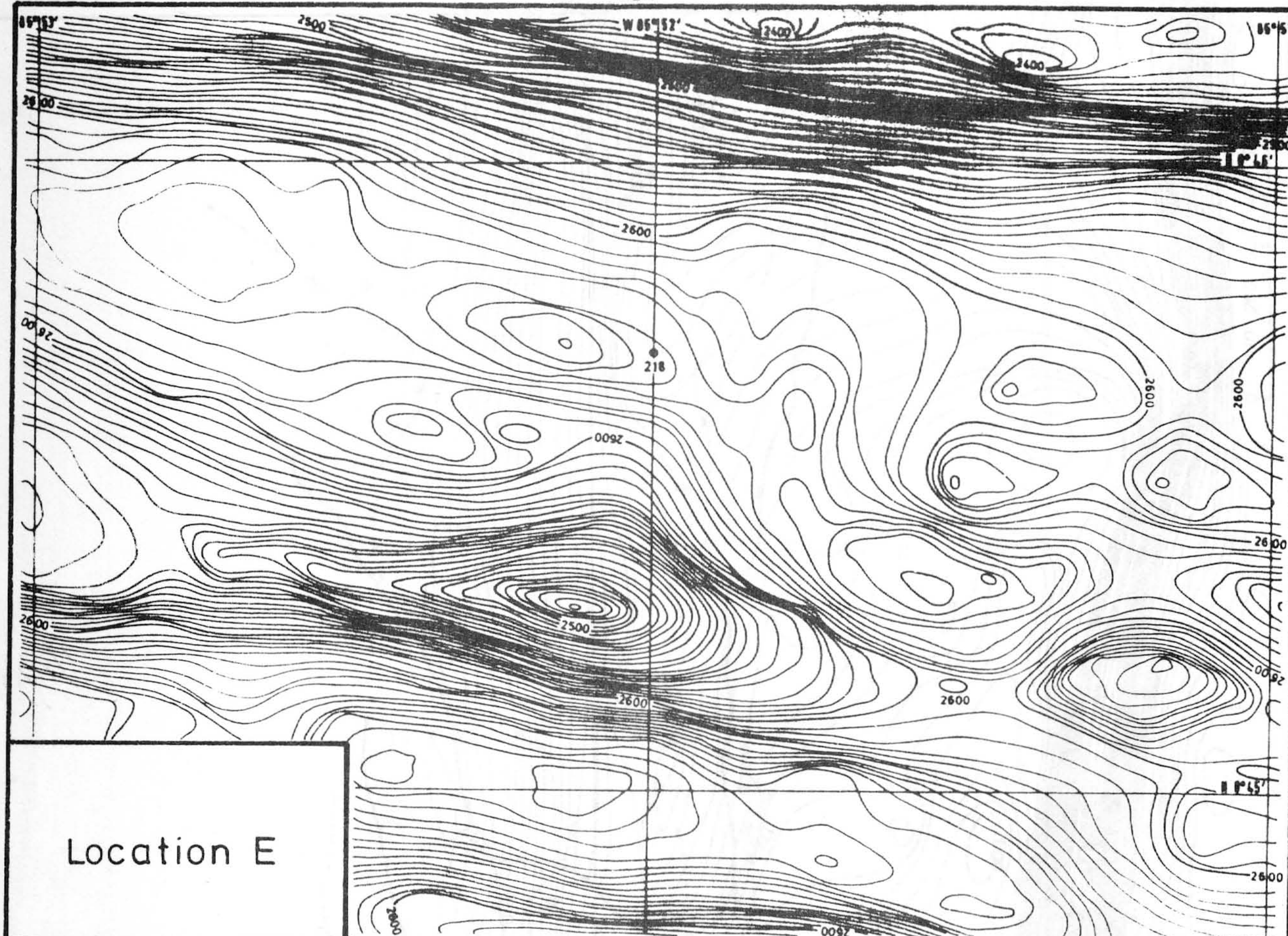


Fig. 12.2.5.:

Location B, SO-39

Sampling positions of volcanic rocks.



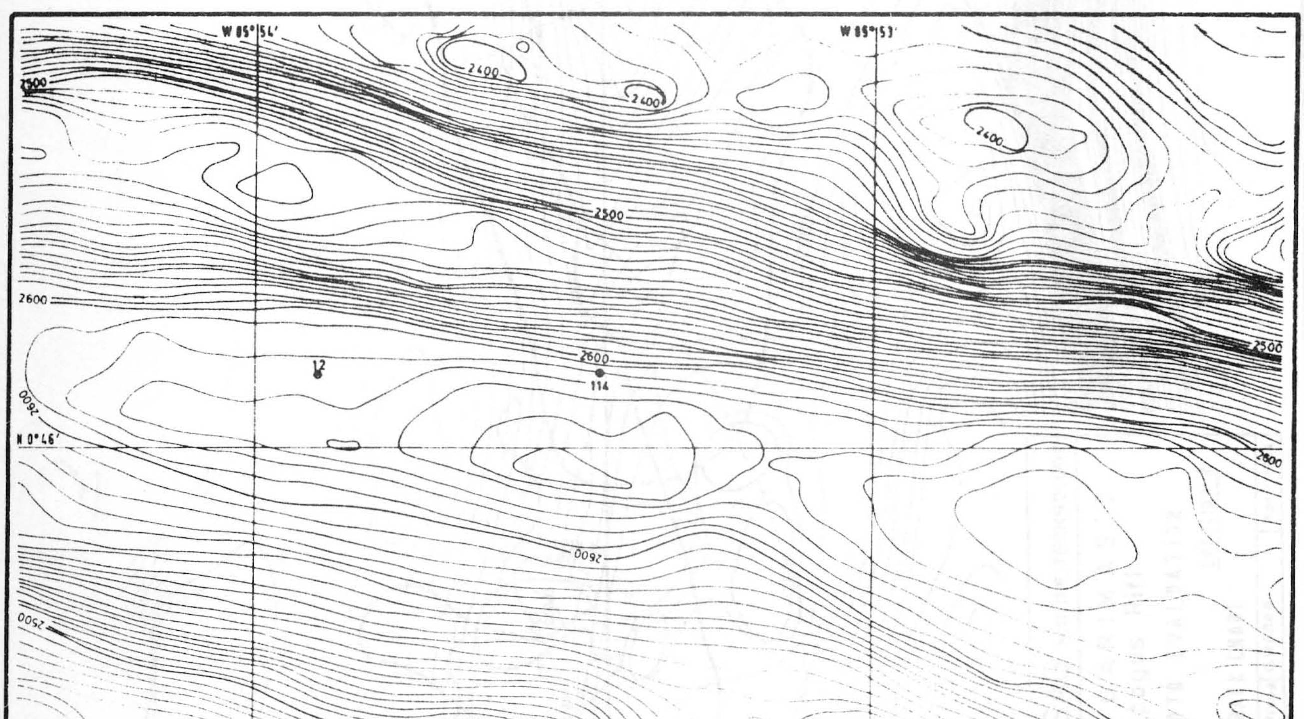
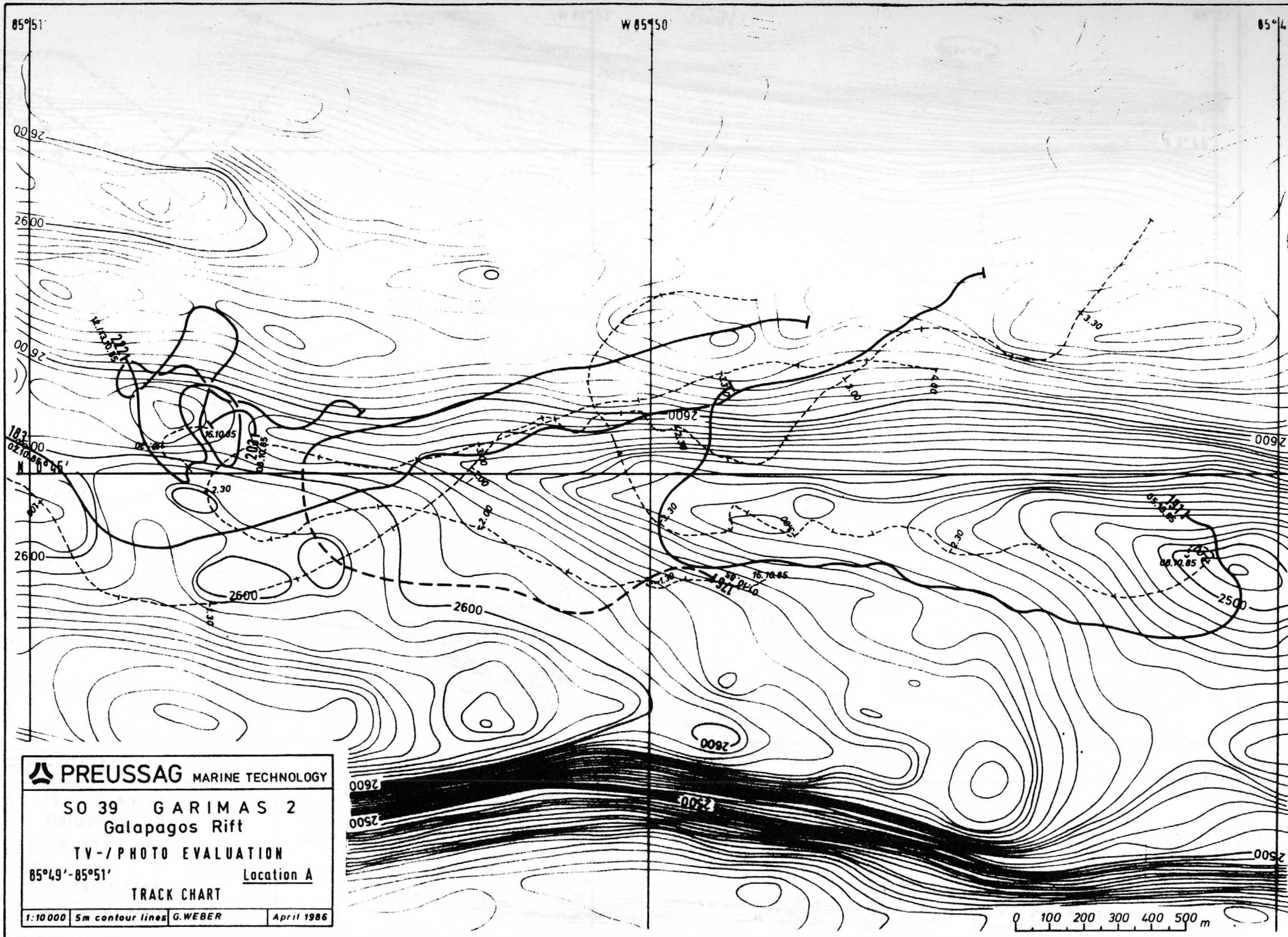
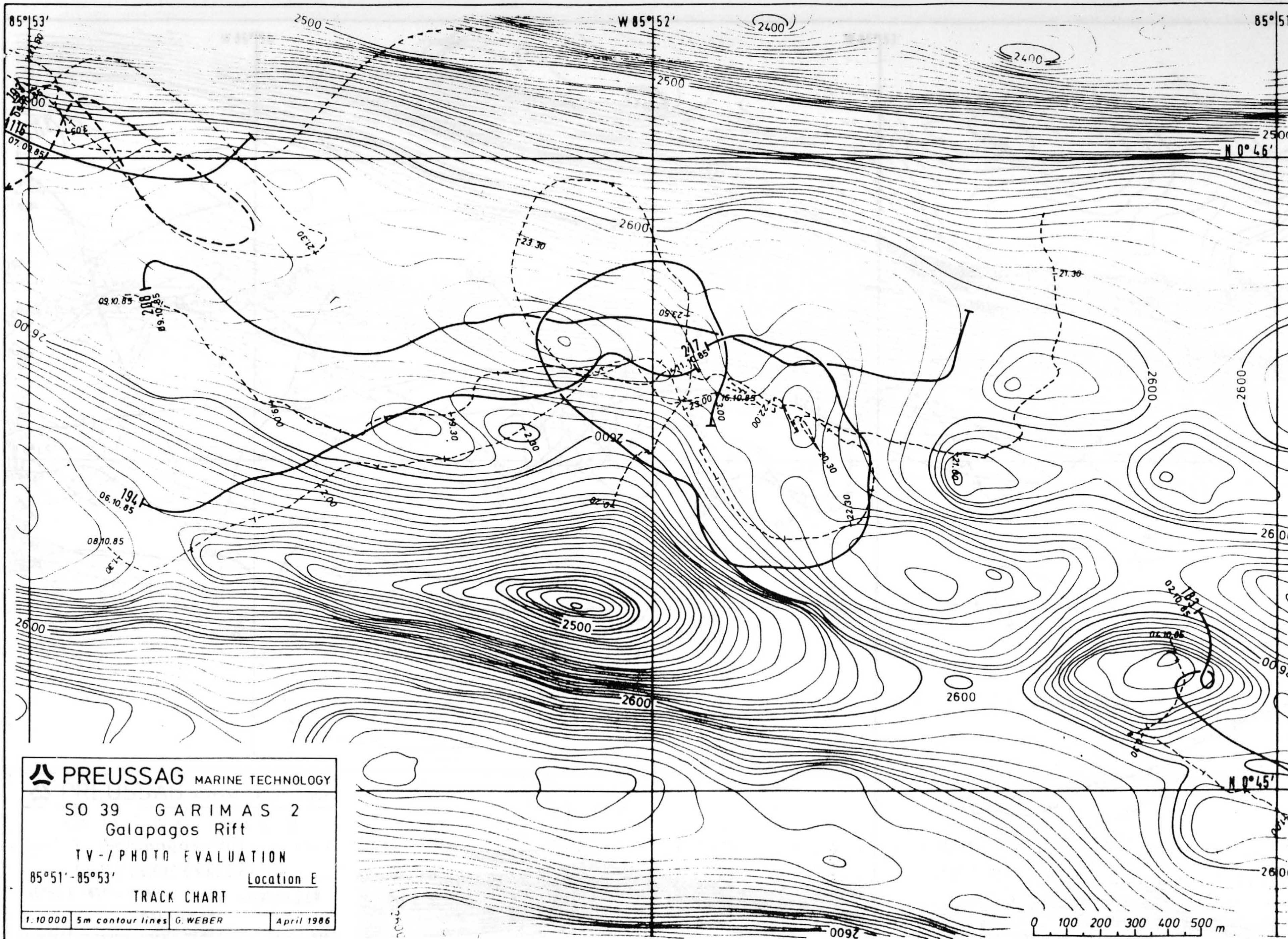


Fig. 12.2.6. : Sampling positions of volcanic rocks, Locations C-E.



85°51'
W 85°50'
85°49'
N 0°45'
2600
2500
PREUSSAG MARINE TECHNOLOGY
SO 39 GARIMAS 2
Galapagos Rift
TV-/PHOTO EVALUATION
85°49'-85°51'
Location A
TRACK CHART
1:10000
5m contour lines
G.WEBER
April 1986
0 100 200 300 400 500 m

Fig. 12.2.7



PREUSSAG MARINE TECHNOLOGY
SO 39 GARIMAS 2
Galapagos Rift
TV-/PHOTO EVALUATION
85°51'-85°53'
Location E
TRACK CHART
1.10000
5m contour lines
G. WEBER
April 1986
85°53'
W 85°52'
85°51'
N 0°46'
N 0°45'
2400
2500
2600
0 100 200 300 400 500 m

Fig. 12.2.8

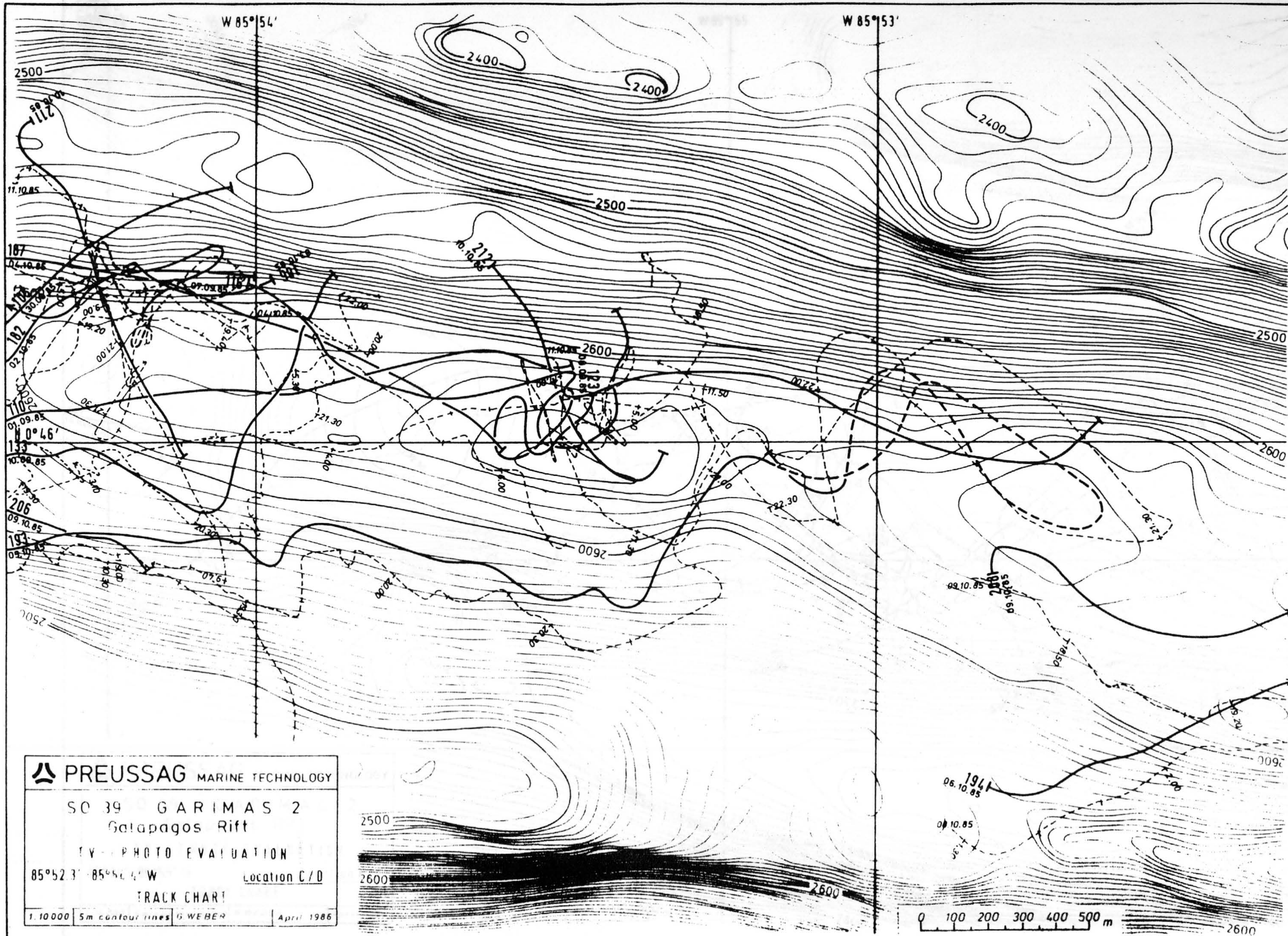

PREUSSAG MARINE TECHNOLOGY
SO 39 GARIMAS 2
Galapagos Rift
TV - PHOTO EVALUATION
Location C/D
TRACK CHART
1:10000
5m contour lines
G. WEBER
April 1986
W 85°54'
W 85°53'
N 0°46'
2400
2500
2600
0 100 200 300 400 500 m

Fig. 12.2.9

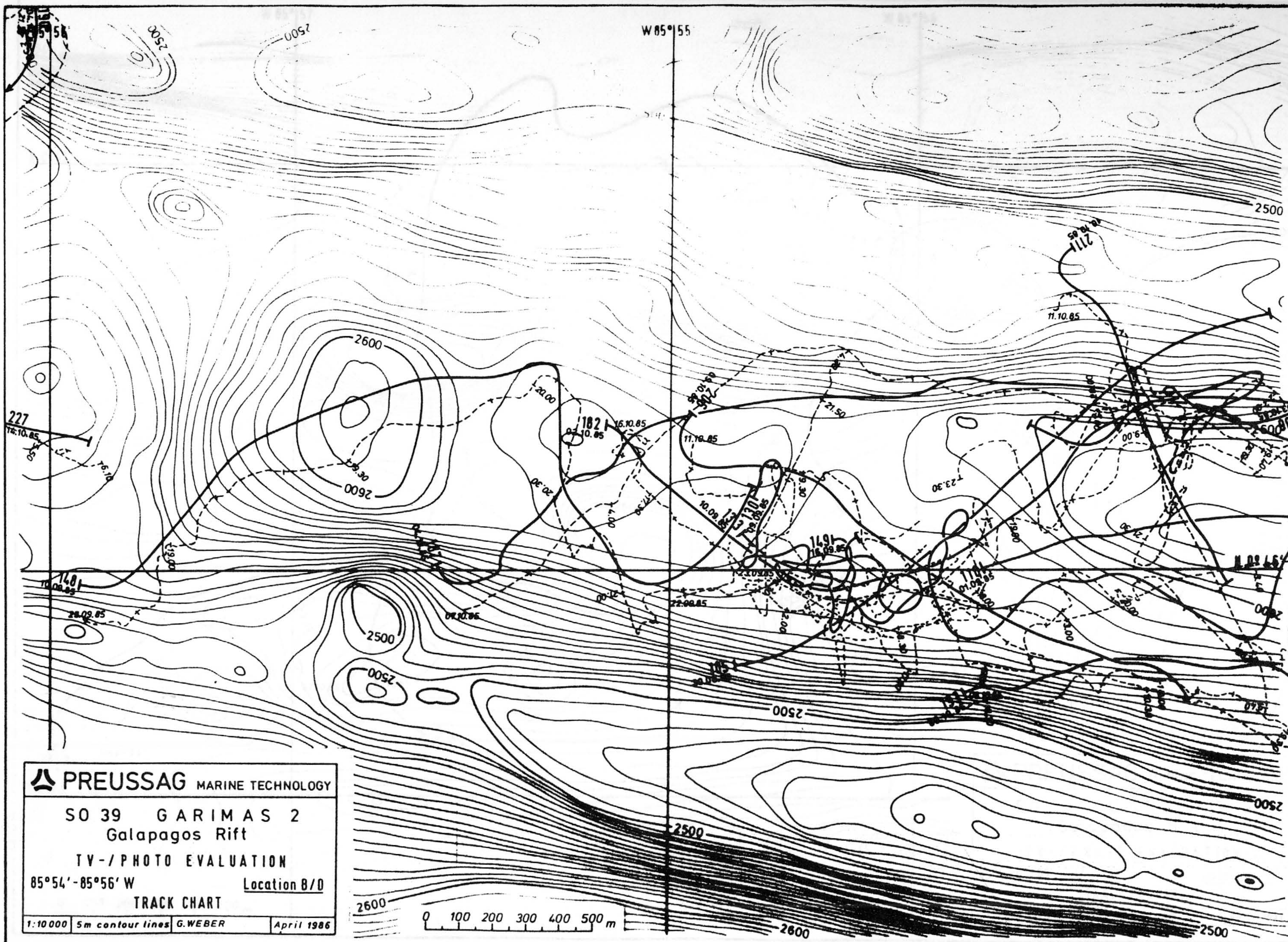

W 85°55
W 85°56
2500
2600
PREUSSAG MARINE TECHNOLOGY
SO 39 GARIMAS 2
Galapagos Rift
TV-/PHOTO EVALUATION
85°54'-85°56' W
Location B/D
TRACK CHART
1:10 000
5m contour lines
G.WEBER
April 1986
0 100 200 300 400 500 m

Fig. 12. 2.10

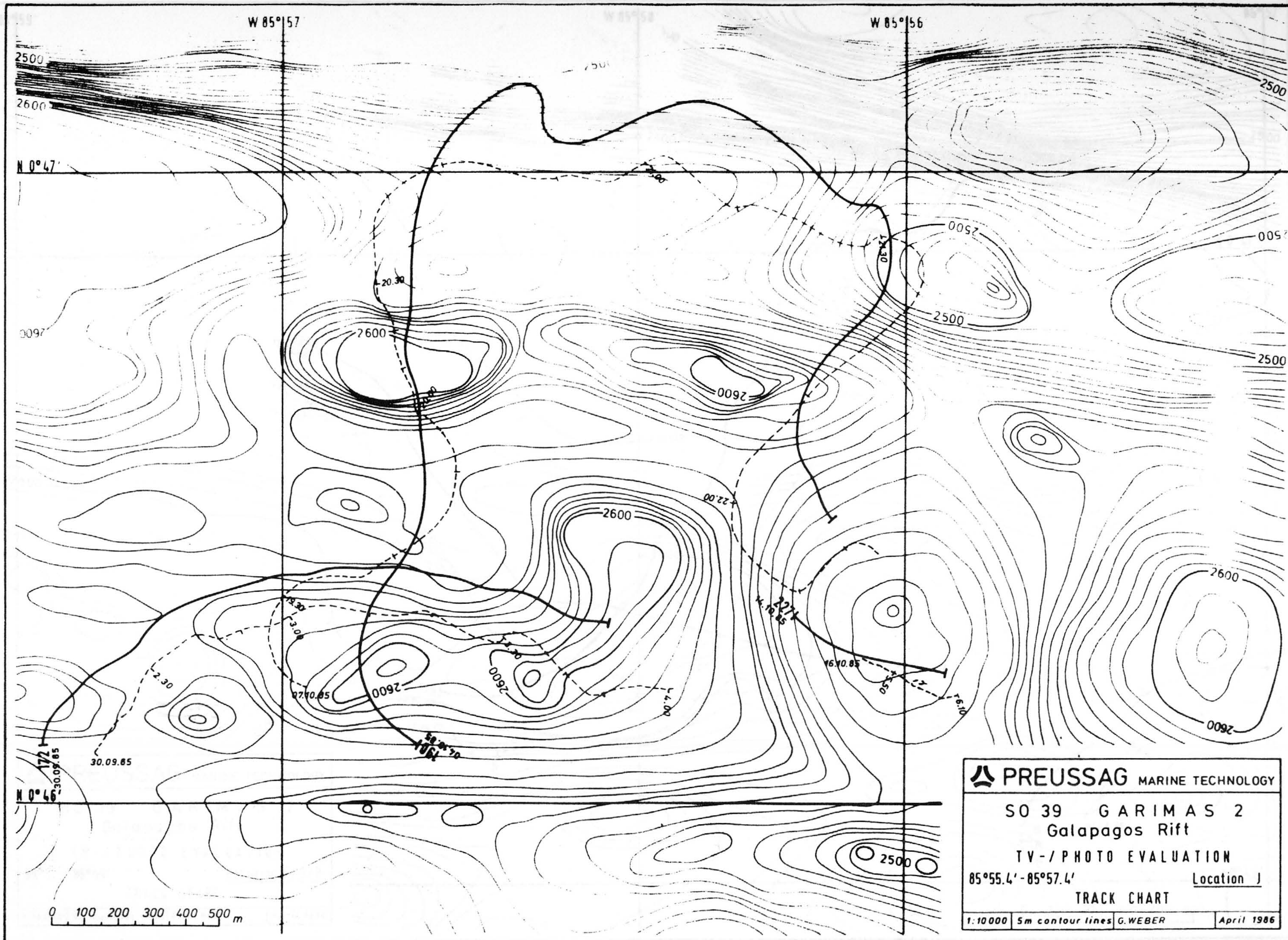

W 85°57
W 85°56
N 0°47'
N 0°46'
2500
2600
PREUSSAG MARINE TECHNOLOGY
SO 39 GARIMAS 2
Galapagos Rift
TV-/PHOTO EVALUATION
85°55.4'-85°57.4'
Location J
TRACK CHART
1:10 000
5m contour lines
G.WEBER
April 1986
0 100 200 300 400 500 m

Fig. 12.2.11

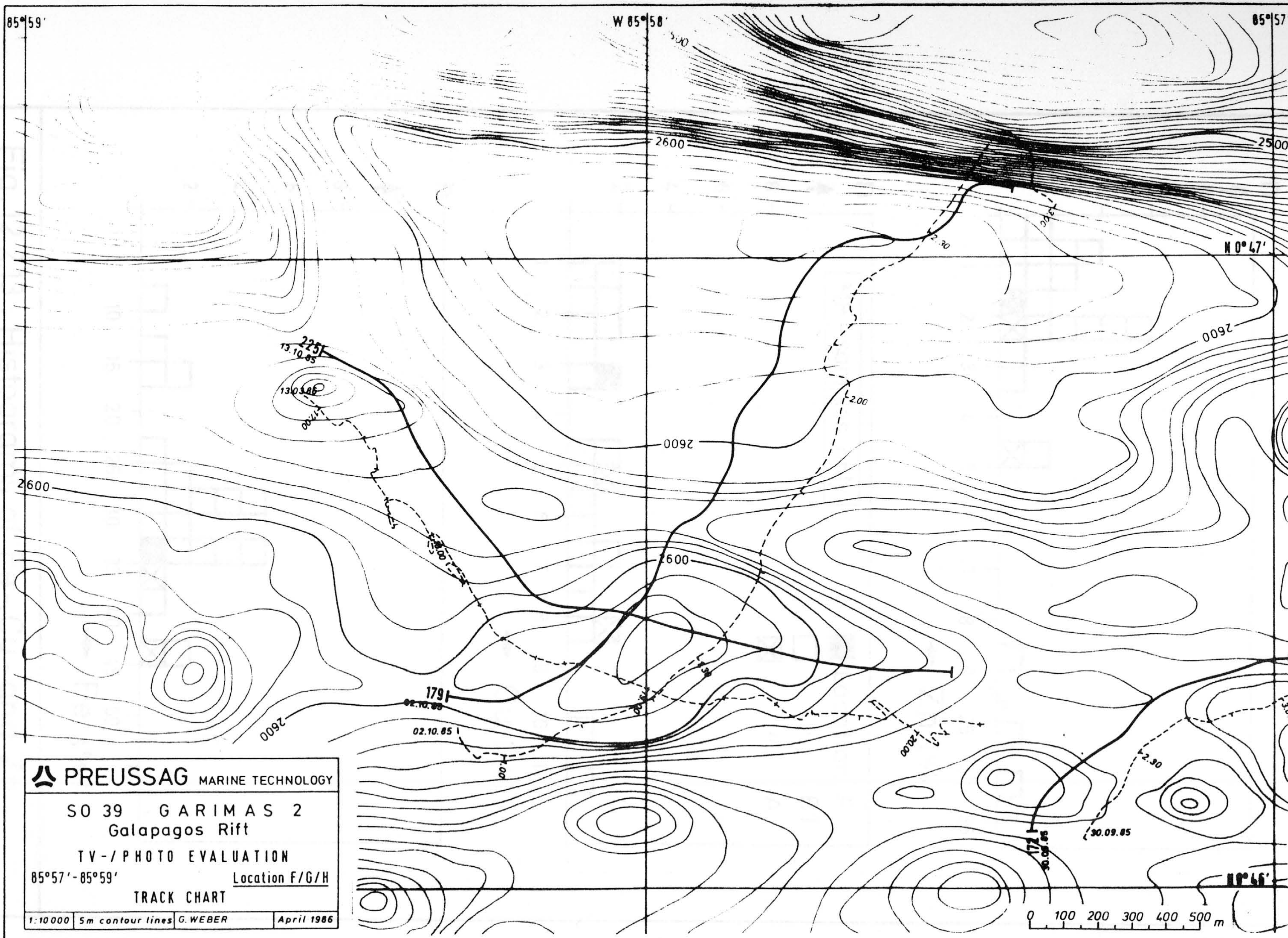

85°59'
W 85°58'
85°57'
N 0°47'
N 0°46'
2600
2500
225
13.10.85
179
02.10.85
172
30.09.85
2.00
2.30
3.00
0 100 200 300 400 500 m
PREUSSAG MARINE TECHNOLOGY
SO 39 GARIMAS 2
Galapagos Rift
TV-/PHOTO EVALUATION
85°57'-85°59'
Location F/G/H
TRACK CHART
1:10000
5m contour lines
G. WEBER
April 1986

Fig.12.2.12

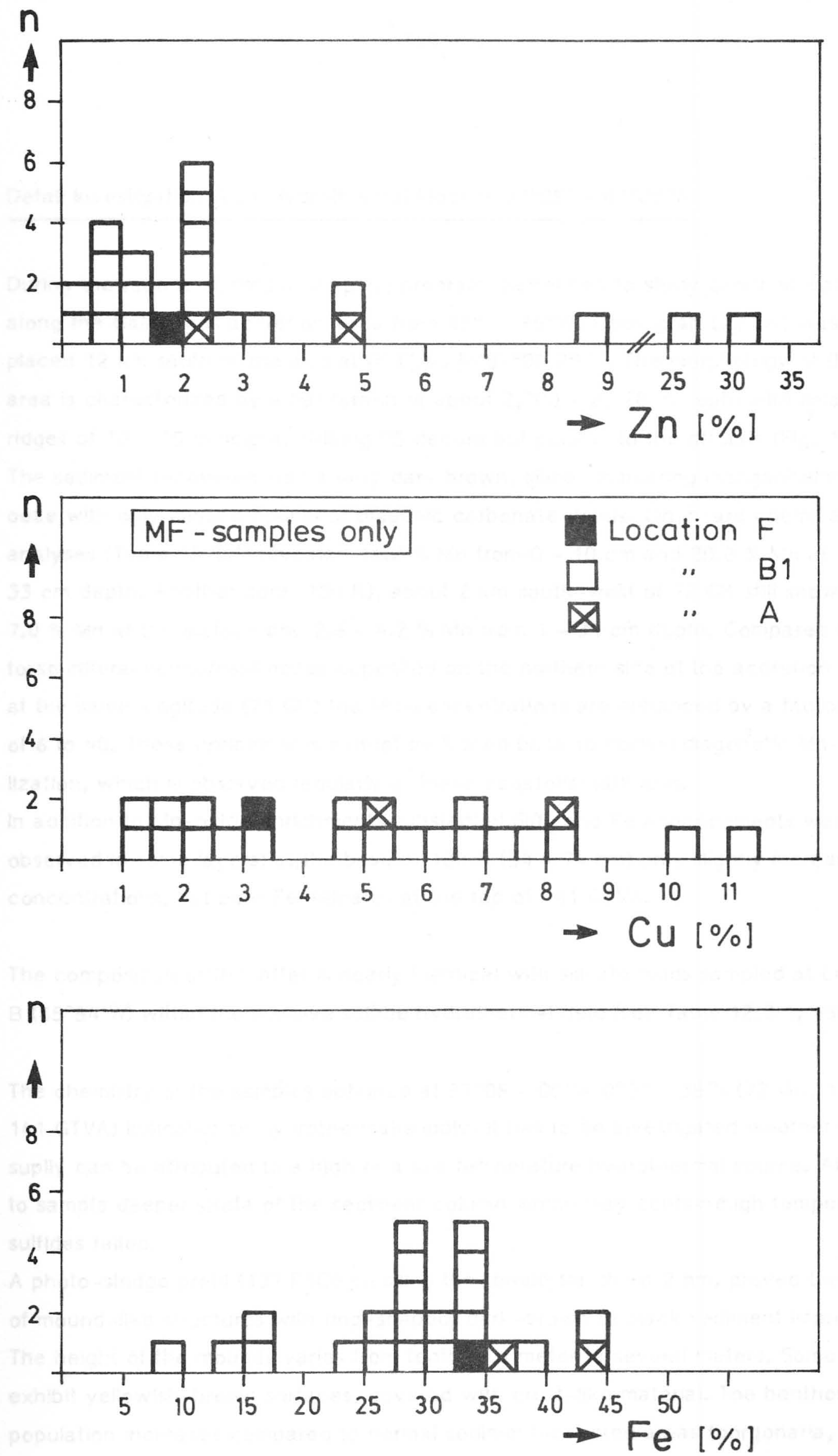


Fig. 12.2.13 : Histograms of Fe-, Cu- and Zn-concentrations in massive sulfides.

12.3 Detail Investigation Area Hydrothermal Mounds 87°08' - 87°09'W

During the routine sediment sampling program, performed to study geochemical halos along the Galapagos accretion zone from 85° to 95°W, a box grab (72 GK) was placed 12 km south of the axis at 0°37.64 N/87°08.29 W. The morphology of this area is characterized by a flat terrain of about 2,700 - 2,720 m depth with small ridges of 10 - 15 m height, striking 95 degree but parallel to the rift axis (Fig. 12.3.1). The sediment recovered was a very dark brown, siliceous bearing manganiferous ooze with only minor amounts of biogenic carbonate debris. On-board chemical analyses (Table 12.3.1) revealed 16.2 % Mn from 0 - 10 cm and 20.8 % Mn at 11-33 cm depth. Another core (100 K), about 2 km south-west of 72 GK still showed 7.0 % Mn at the surface and 2.6 - 4.2 % Mn from 1 - 31 cm depth. Compared to foraminiferal nannofossil oozes deposited on the northern side of the accretion zone at the same longitude (71 GK) the Mn-concentrations are enhanced by a factor of 6 to 40. These enrichments cannot be traced back to normal diagenetic Mn-mobilization, which is observed regularly at these equatorial latitudes.
In addition to Mn-oxide enrichments substantial SiO_2 and Fe enhancements were observed in some layers: at the base of 100 K (54 - 74 cm) only slightly increased concentrations, but pure Fe-silicates at the top of 141 GTVA.

The composition of the latter is nearly identical with silicate muds sampled at Location B (85°54'W) within the massive sulfide hydrothermal field (see Table 12.3.1, 150 GTVC).

The chemistry of the samples obtained at 87°08 - 09'W/0°37 - 38'N (72 GK, 100 K, 141 GTVA) indicates an hydrothermal supply. It has to be investigated whether this suplly can be attributed to a high or a low temperature hydrothermal source. Attempts to sample deeper strata of the sediment column which may contain high temperature sulfides failed.
A photo-sledge profil (137 FSO) crossing the terrain for about 2 nm, proved the existence of mound-like structures with ring-shaped, dark-brown to black sediment impregnations. The height of the mounds varies from tenth of a meter to several meters. Some mounds exhibit yellowish-brown surfaces, covered with crust-like material. The benthos-population increases compared to normal sediment-covered areas (gorgonaria, galathea). The mounds are frequently located over small (less than a meter) vertical displacements of the surface.

Most of the observations and analyses lead us to models of mounds formation as a result of precipitation of materials from low temperature hydrothermal solutions. The presence of Mn-oxide or Fe-silicate rich surface layers combined with the enhanced benthos population imply that the hydrothermal activity has not ceased. Unfortunately no temperature data of bottom waters or sediment heat-flow values are available.

Similar low temperature hydrothermal mounds, consisting primarily of Mn-oxides and nontronitic clays, have already been found at sites 506, 507 and 509 of Leg 70 (DSDP) at about 86°05 - 08'W/0°33 - 36'N. These mounds are located even more south of the recent accretion axis (20 - 30 km) over crust 0.5 to 0.9 Ma in age (Honnorez et al., 1981).

TAB. 12.3.1: SEDIMENT CHEMISTRY AT 87°08'W MOUND AREA AND REFERENCE SEDIMENT SAMPLES (ON-BOARD ANALYSES)

STATION NO.	DEPTH IN CORE (CM)	SAMPLE NO.	MN %	FE %	CO ppm	NI ppm	SIO_2 %	CAO %	$CACO_3$ %	MN/FE	REMARKS
71 GK	0 - 16	BAC 1	1.9	1.5	-	320	6.8	34.4	61.6	1.26	86°58'W
71 GK	16 - 22	BAC 2	0.11	2.2	< 30	70	19.2	41.2	68.9	0.05	"
71 GK	22 - 40	BAC 3	0.07	1.6	< 30	70	18.8	40.6		0.04	"
72 GK	0 - 10	BAC 4	16.2	1.7	< 30	240	6.7	5.6		9.53	Mound area
72 GK	11 - 33	BAC 5	20.8	2.4	< 30	330	15.0	21.7	22.5	8.67	"
72 GK	Mn-crust	BAC 6	35.9	0.7	< 30	330	1.8	2.8		59.83	"
73 GK	0 - 16	BAC 7	0.16	1.0	< 30	40	14.1	41.9	70.2	0.17	87°39'W
98 GK	average	BAC 19	0.04	2.1	< 30	30	23.1	38.1	66.0	0.02	90°15'W
99 GK	0 - 10	BAC 20	0.43	1.4	< 30	70	23.7	37.5	65.3	0.31	90°12'W
99 GK	10 - 25	BAC 21	0.05	1.4	< 30	40	22.2	38.7	69.3	0.04	"
99 GK	25 - 41	BAC 22	0.05	1.8	< 30	40	24.3	36.4	64.7	0.03	"
100 K	surface	BAC 23	7.0	1.7	< 30	340	23.0	28.7	44.0	4.12	Mound area
100 K	0 - 6	BAC 24	4.2	1.5	< 30	269	24.4	32.5	52.0	2.80	"
100 K	6 - 31	BAC 25	2.6	1.5	< 30	284	24.4	34.4	60.0	1.73	"
100 K	31 - 54	BAC 26	0.59	2.0	< 30	170	25.5	34.5	62.7	0.30	"
100 K	54 - 74	BAC 27	0.43	3.5	< 30	150	33.0	31.6	54.7	0.12	"
136 GK	surface	BAC 39	2.6	1.9	< 30	340	23.5	32.7	56.1	1.36	86°31'W
136 GK	0 - 13 cm	BAC 36	1.4	1.8	< 30	190	23.8	34.1	59.5	0.78	"
136 GK	13 - 24	BAC 37	0.39	2.1	< 30	100	22.7	36.6	70.9	0.19	"
136 GK	24 - 39	BAC 38	0.13	2.1	< 30	110	23.1	36.7	68.2	0.06	"
141 GTVA	surface	BAC 40	0.50	21.5	40	40	46.3	4.5	< 5	0.02	Mound area
141 GTVA	0 - 5	BAC 41	3.3	1.7	< 30	280	23.5	33.8	56.8	1.94	"
141 GTVA	6 - 14	BAC 42	2.6	2.1	< 30	240	21.0	34.6	61.5	1.24	"
141 GTVA	15 - 60	BAC 43	0.40	2.4	< 30	140	27.8	34.1	61.5	0.16	"
150 GTVC	surface	BAC 44	0.21	23.7	50	20	44.3	1.2	< 5	0.01	Location B

Analysts: K. Becker, P. Herzig (RWTH Aachen)

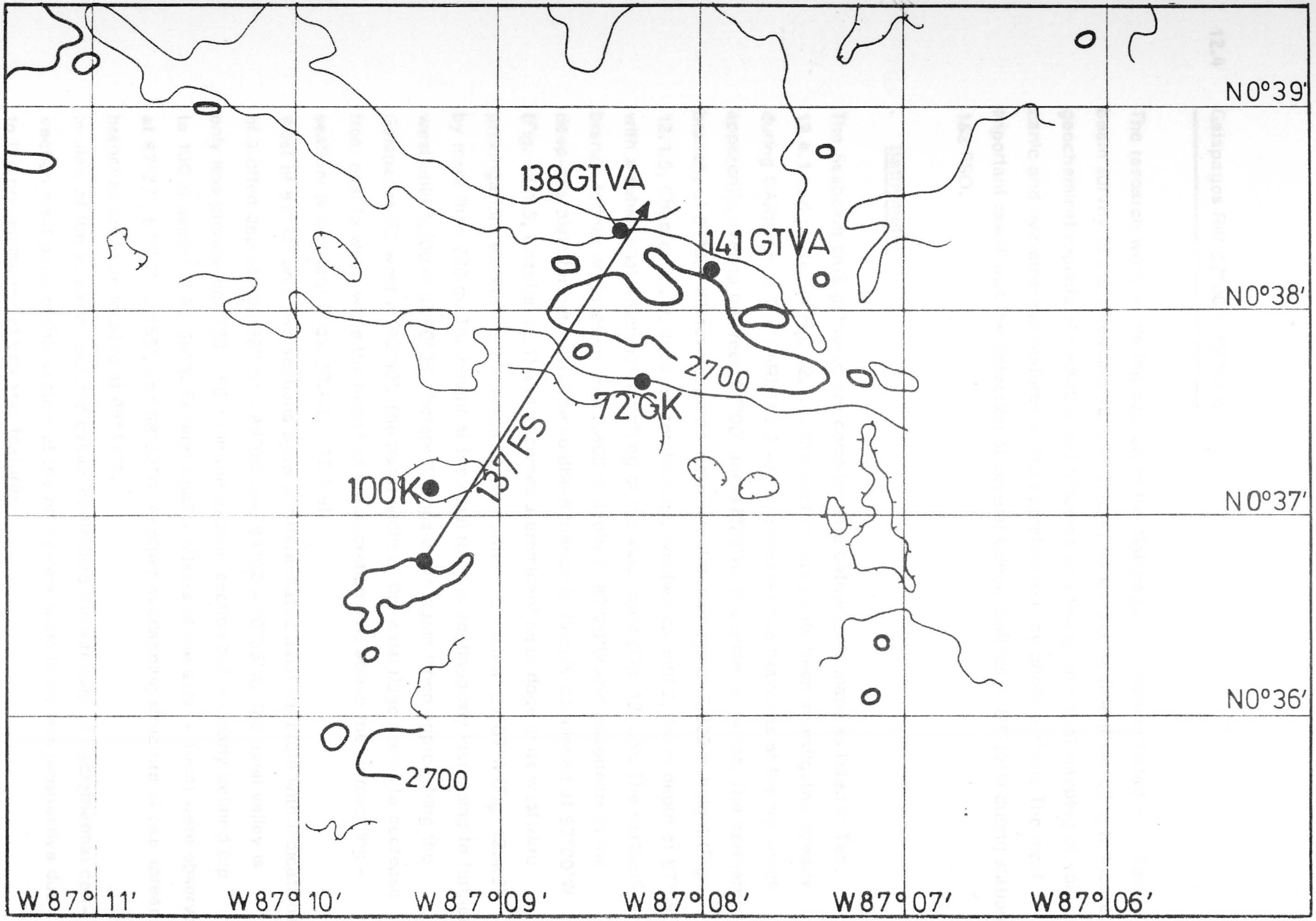


Fig.12.3.1 : Bathymetry and stations at hydrothermal mounds area 87°08'/09'W

12.4 Galapagos Rift 87°00 - 90°50'W

The research work within this section of the Galapagos Rift concentrated on a Seabeam survey of the spreading zone structure, on surface sediment sampling to locate geochemical imprints of hydrothermal effluents and finally on visual mapping of volcanic and hydrothermal features of the accretion axis by photo profiles. The most important result was the detection of several sulfide edifices at 89°19'W during station 162 FSO.

. Bathymetry

The Seabeam data gathered are compiled in 6 bathymetric maps as listed in Tab. 12.4.1 and plotted in Fig. 12.4.1. This section has partly been investigated already during GARIMAS 1. The GARIMAS 2 survey revealed two branches of the rift which apparently overlap between 87°00' and 87°20'W. The offset is 14 km. The northern branch, at 87°00 still developed as a prominent axial ridge of 2,200 m height (Fig. 12.1.5, Chapter 12.1), declines continuously westwards until 2,350 m depth at 87°09'W with a substantial widening and rifting of the axial zone (Fig. 12.4.3). The northern branch further drops down until 2,600 m depth at 87°20'W and disappears in the deep-sea plain further west. The southern branch is already developed at 87°00'W (Fig. 12.1.5, Chapter 12.1) and becomes a prominant axial ridge in its westward prolongation, exceeding the height of the northern branch at 87°09'W (Fig. 12.4.3) by more than 200 m. The height of the axial ridge is continuously increasing to further west until 1,500 m at 90°35', before it drops down again when approaching the Galapagos FZ west of 90°40'. The basal width of the axial ridge seems to decrease from east to west, while the height of the accretion axis above the surrounding - seafloor is constant (Figs. 12.4.2 - 12.4.6).

West of 87°30' only two sections show a differentiated axial structure with indications of a rifted depression: 88°25' - 89°08' and 89°52 - 90°05'W. The axial valley is only less pronounced (20 - 50 m) in the eastern section but is clearly defined (up to 100 m depth) at 89°56'W. Several smaller offsets of the axis (- 1 nm) were observed at 87°27', 87°51', 87°55', and 88°32'W. Another overlapping structure of two spreading branches could be located at 89°11'W.

In view of the volcano-tectonic cycles controlling the intensity of hydrothermal convection most parts of this section of the rift system seem to be less prospective due to the predominance of volcanic features.

. Rocks

No attempts to recover rocks took place.

. Sediments

11 box grab stations were placed along this section of the Galapagos Rift in about 5 to 15 km distance to the accretion axis (Fig. 11.4.1, Chapter 11.4). At 87°08/09'W, 12 km south of the axis, a hydrothermal mound site could be detected (see Chapter 12.3). The board analysis of other sediment cores revealed to some extent Mn-enrichments in oxidic surface layers (up to 0.43 %) but no conclusive hydrothermal impact could be stated. The thickest oxidic layers (17 - 18 cm) were observed in 163 and 164 GK, two stations located along sections with a rifted depression. Only during Leg 3 sediments recovered were analyzed on-board (see Tab. 12.3.1, Chapter 12.3). Therefore conclusive results have to be waited for.

. Visual observations and hydrothermal indications

Outside of the hydrothermal mound area at 87°08'W only 7 photo-profiles were run along and crossing the accretion axis: 139 FS at 87°56', 140 FS at 87°42', 142 FS at 87°24, 143 FS at 87°10', 162 FS at 89°19', 165 FS at 88°24' and 166 FS at 88°08'W. Only at 89°19'W indications of subrecent high temperature hydrothermalism could be detected (Fig. 12.4.7):

162 FSO	0.27 - 0.29 h	1690 M: HH = irregular stacks (sulfides?) of dark grey colour; at base brown sediment coloration; pillow lava terrain, 10 % sediment.
	2.02 h	1677 m: HH = small mounds (sulfidic?) with strong benthos population; nodular ponded lava and pillow lava terrain; 20 - 30 % sediment; sequence of deep and broad as well as small fissures.

TAB. 12.4.1: BATHYMETRIC MAPS 87°00'W - 90°50'W

	LONGITUDE/LATITUDE	SCALE	CONTOUR INTERVAL
1.	W 86°55' - 87°35' N 1°01' - 0°47'	1 : 50.000	20 m
2.	W 87°00' - 88°00' N 0°49' - 0°35'	1 : 50.000	20 m
3.	W 87°30' - 88°45' N 1°04' - 0°50'	1 : 50.000	20 m
4.	W 87°55' - 89°00' N 0°54' - 0°40'	1 : 50.000	20 m
5.	W 88°55' - 90°00' N 0°54' - 0°40'	1 : 50.000	20 m
6.	W 89°50' - 90°50' N 1°05' - 0°45'	1 : 50.000	20 m

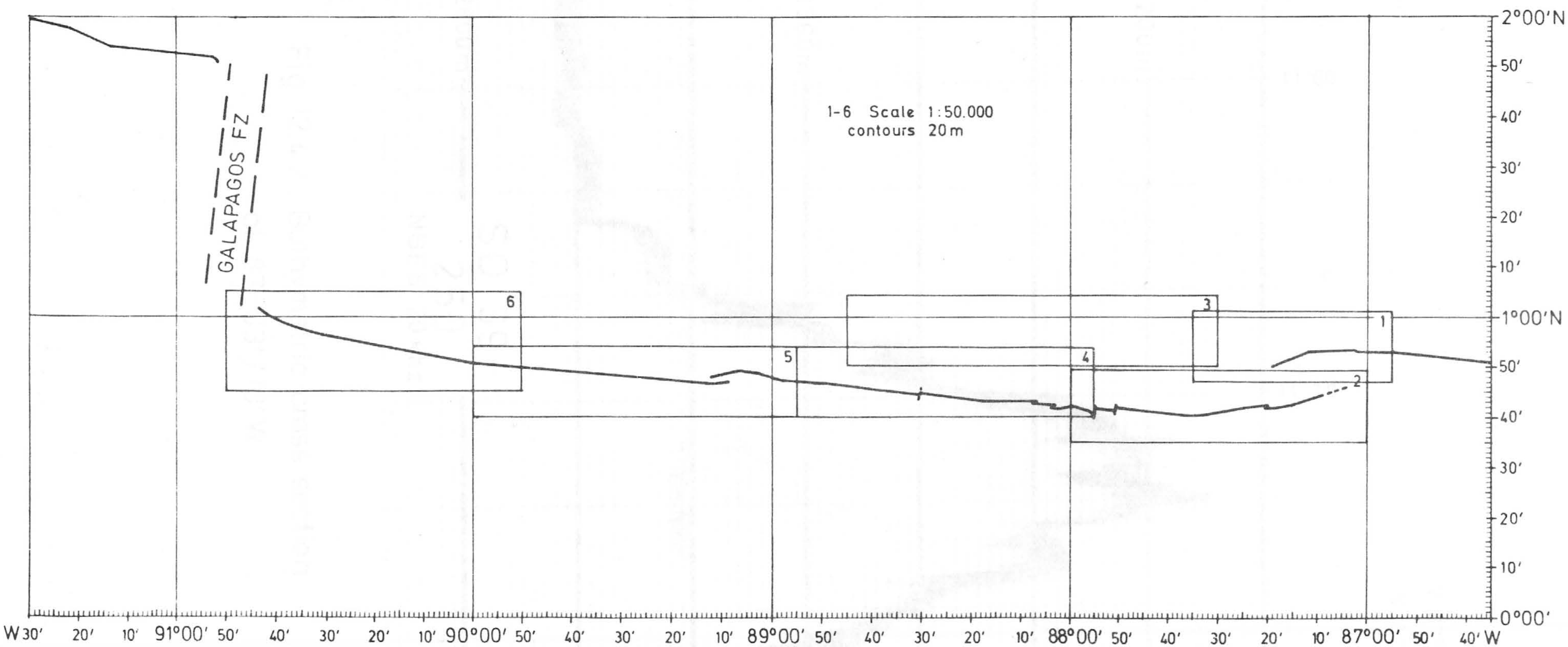


Fig. : 12.4.1. : SO-39 bathymetric maps: 87°00'-90°50'W

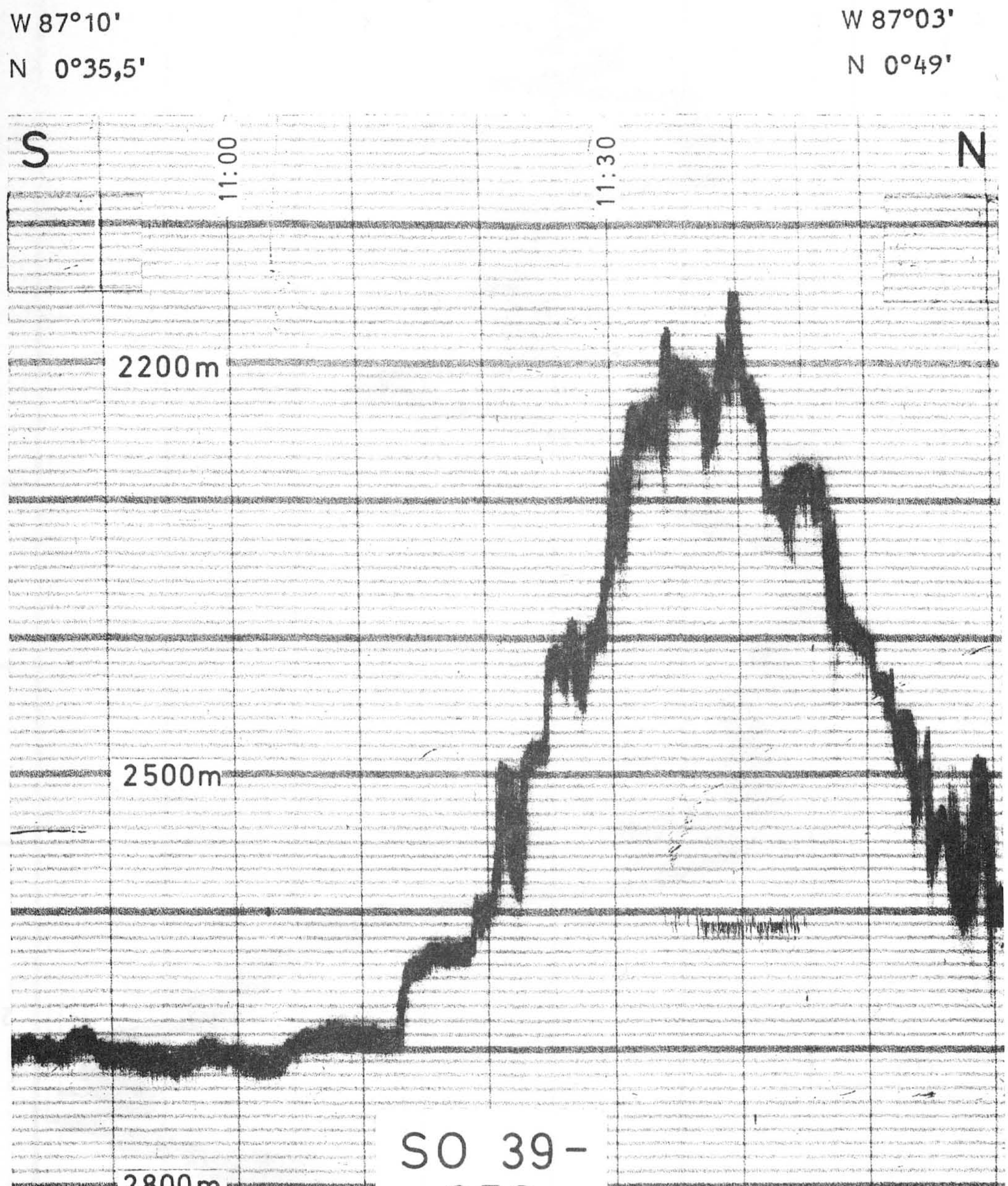


Fig. 12.4.2 : Bathymetric cross section at 87°03'/10' W.

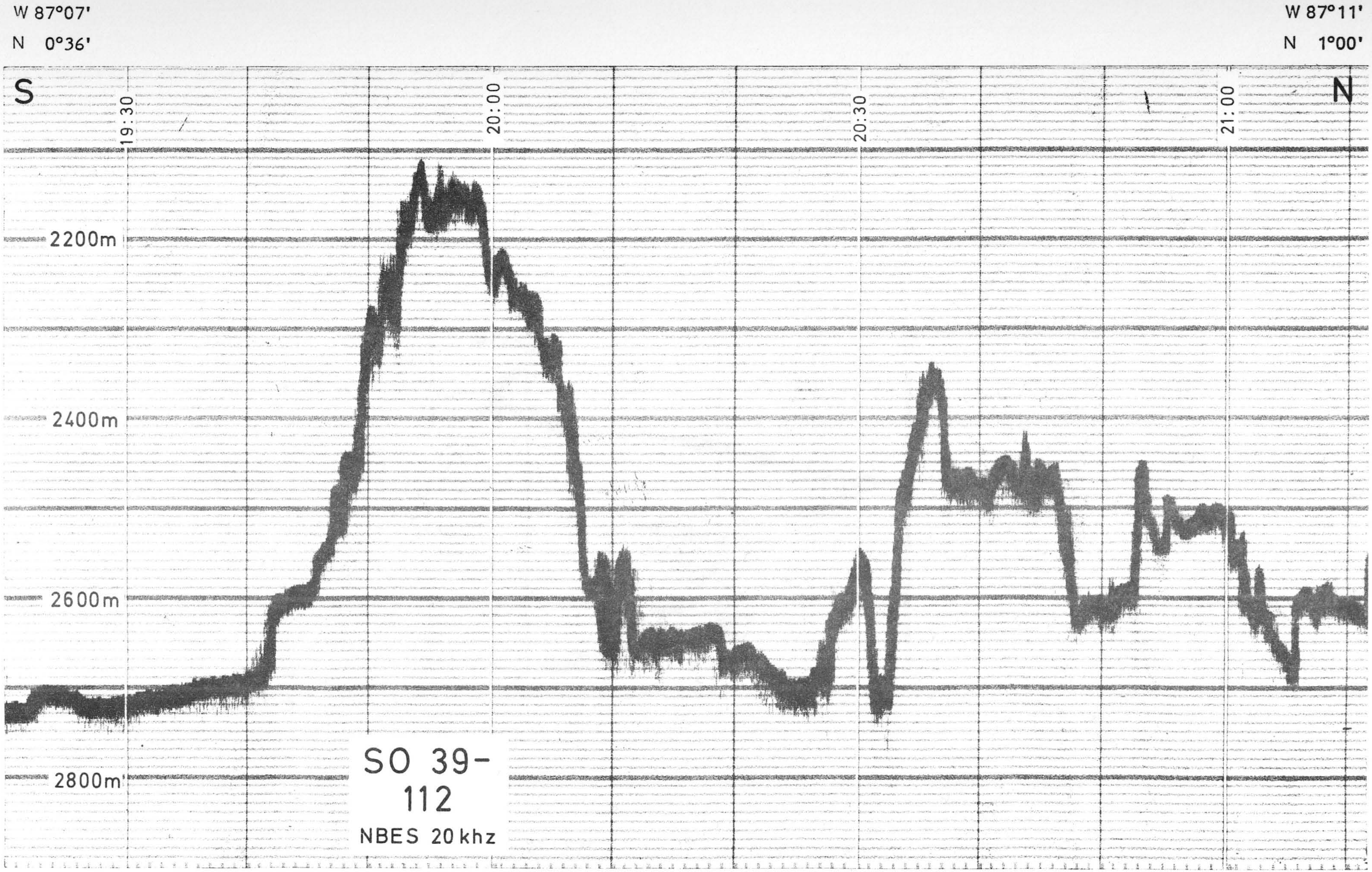


Fig. 12.4.3 : Cross section of OSC
at 87°07'/11'W.

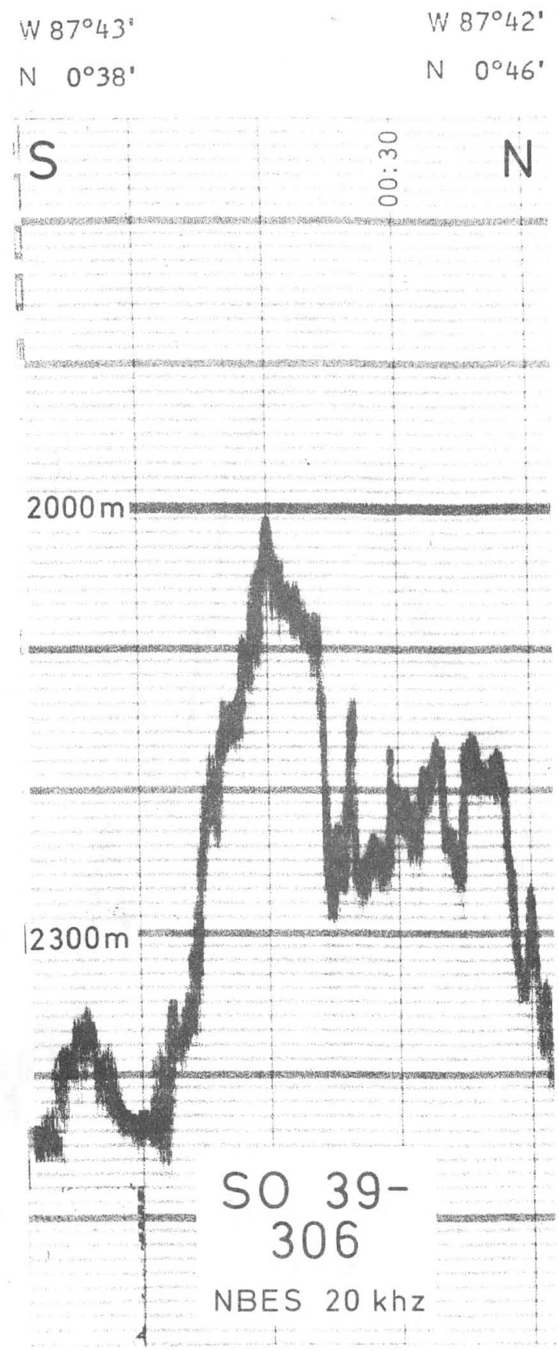


Fig.12.4.4: Bathymetric cross section at 87°42'/43' W.

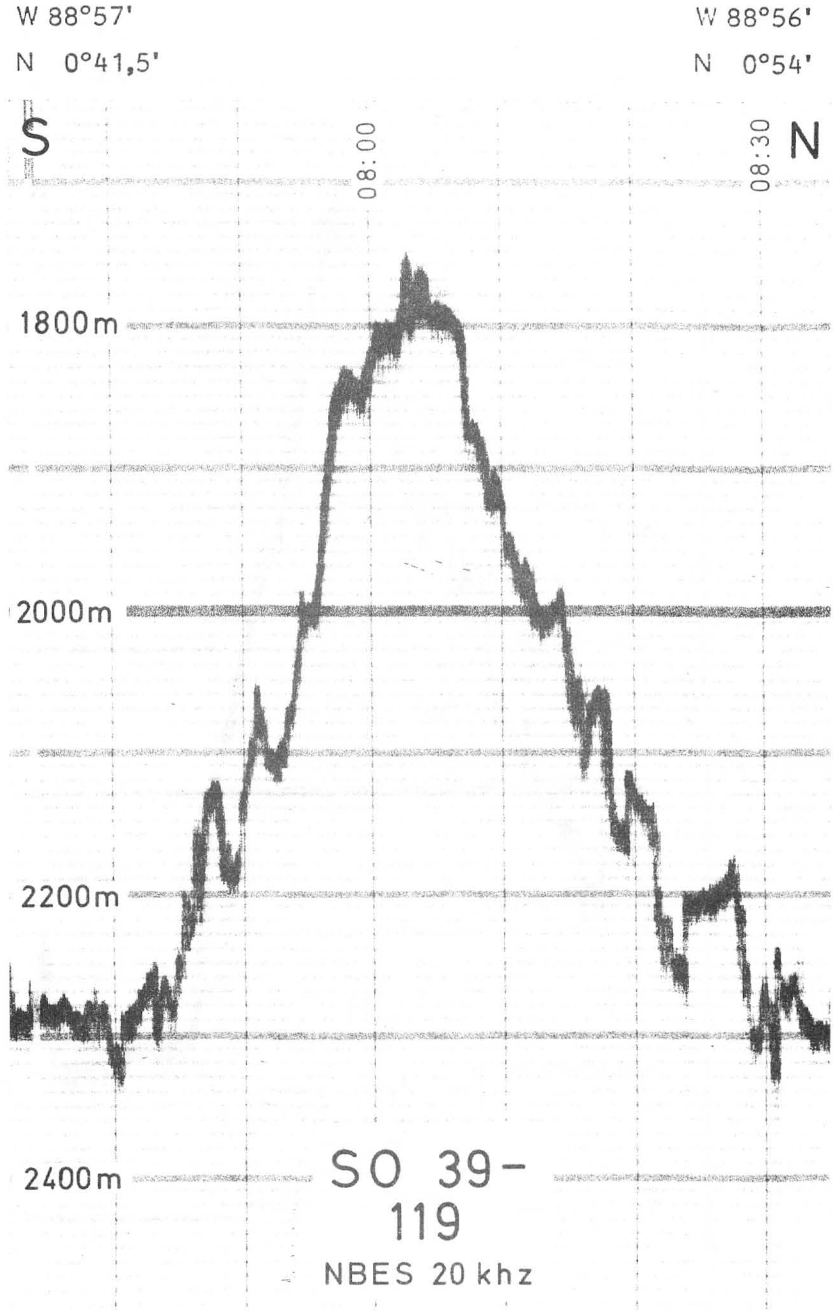


Fig. 12.4.5 : Bathymetric cross section
at 88°56'/57' W.

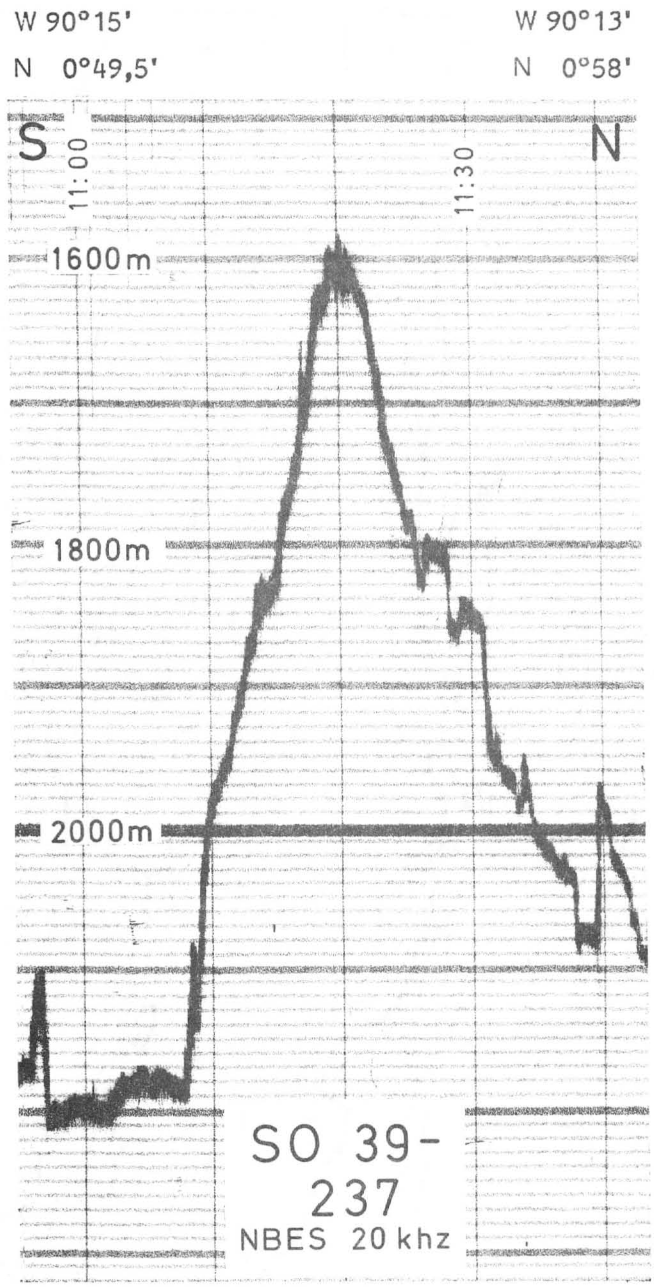


Fig. 12.4.6 : Bathymetric cross section
at 90°13'/15' W.

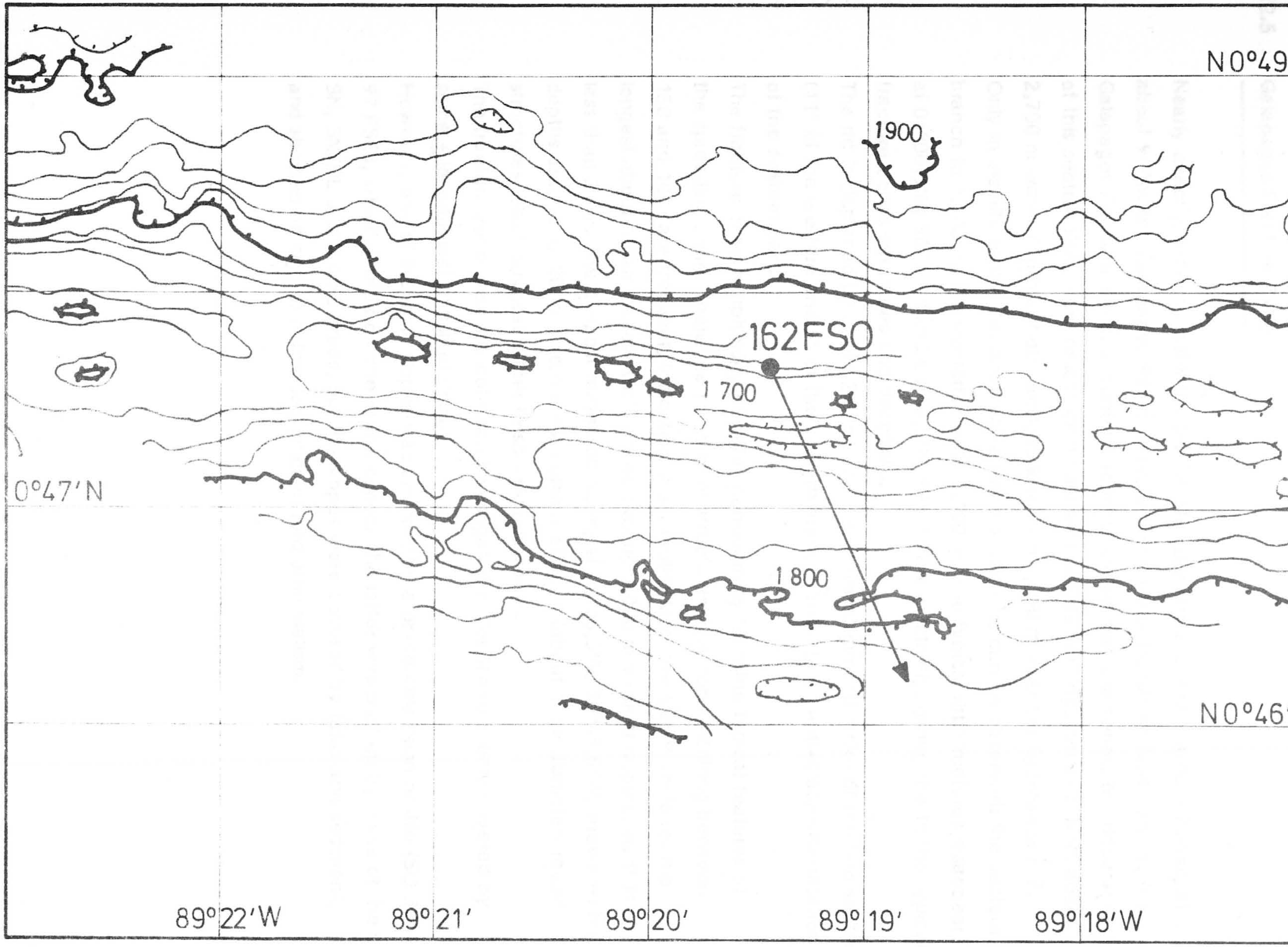


Fig. 12.4.7 : Location of massive sulfides (162 FSO)

12.5 Galapagos Fracture Zone

Nearly exactly mid-way between the De Steiguer and the Inca Fracture Zones, at about 91°W, the Galapagos Rift is dissected by a major transform fault system, the Galapagos Fracture Zone. In contrast to most known fracture zones, the ridge axis of this section rises more or less continuously towards the displacement, from about 2,700 m water depth at both ends, to less than 1,600 m near the Galapagos F.Z. Only in vicinity of the displacement a slope of the axis can be observed: the eastern branch to 1,700 m, the western one to 2,100 m. The typical rift structures disappear at 01°00,5'N; 90°42'W and 01°52,5'N; 90°53'W respectively, giving rise to the typical fracture zones structures and directions.

The rift is displaced by about 29 km, and the different general strike of the two sections (11° of the western and 5° of the eastern branch) indicate an anti-clockwise rotation of the eastern part.

The fracture zone morphology deviates considerably from the typical features of the spreading zone. There are many bent structures, but slopes striking between 150 and 180° are frequent, indicating sheer faults. Most are 4 to 9 km long, the longest about 13 km. A few such slopes exceed 1,000 m vertical displacement in less than 2 km. The deepest measured basin, at 01°36,5'N; 90°49,5°W, shows water depths around 3,500 m. There are a number of small (about 1 km diameter) round structures which suggest rather fresh volcanic cones.

The fracture zone area has not been investigated in detail and is only covered by some ± longitudinal transit profiles.

However, one of the main slopes was covered by a photo-television profile (SO 39-97 FSO), which started on one of the cones. The latter was built up by lavas of the SN, SN/PL and SN/SL types, but the slopes were covered by talus and sediment, and showed no sign of active tectonics or hydrothermalism.

12.6 Galapagos Rift 90°50'W – 95°30'W

Main task of the research performed within this section of the Galapagos Rift was a Seabeam survey of the spreading zone structure, supplementing existing Seabeam maps of this area based on GEOMETEP 2 and 3 as well as GARIMAS 1 data. In addition, a first visual mapping of volcanic features of the accretion axis by photo profiles was carried out. The detection of a hydrothermal field at 94°58.7'W, indicated by temporarily highly turbid water above the seafloor, was the most important result (see chapter 12.7).

• Bathymetry

The Seabeam data obtained are compiled in 13 bathymetric maps as listed in Tab. 12.6.1 and plotted in Fig. 12.6.1. Track charts are added in ANNEX 5 to this cruise report. The GARIMAS 2 survey confirms the already known overall main along-strike variation of the accretion axis, but adds substantial knowledge about the small-scale variation of the neo-volcanic zone. The along-strike variation west of the Galapagos FZ is characterized by two major features: a prominent axial ridge with little tectonic differentiation is developed between the Galapagos FZ (90°50'W) and 92°33° (Fig. 12.6.2, 12.6.3). The ridge is uplifted to 1,600 m, probably influenced by the Galapagos hot spot. Local axial volcanoes, superimposed on the linear ridge structure, rise up to 1,380 m (91°25'W). Two lateral displacements at 91°33' and 92°14'W do not change the general trend. West of 92°33'W the ridge slopes down towards the De Steiguer Deep (to 3,400 m), on the rim of which some circular axial volcanoes are developed (see detail area 94°46' – 95°05'W, chapter 12.7). At 93°15'W an overlapping spreading centre interrupts the linear trend and offsets the accretion axis about 5 nm to the north (Fig. 12.6.4). West of 93°15' the axial portion of the spreading centre is submerged in respect to the marginal highs and the amount of submergence increases towards the De Steiguer Deep (Figs. 12.6.5 – 12.6.7). In view of volcano-tectonic cycles controlling the probability of hydrothermal convection cells to be developed, only the central part of this working area (92°33'W – 95°05'W) seems to be a prospective zone.

- Sedimentsa

Six box grab stations were placed along this section of the Galapagos Rift in about 5 to 13.9 km distance to the accretion axis (Fig. 11.4.1, chapter 11.4). At one station, located in the centre of the OSC-structure at 93°15'W, only volcanic glass fragments were recovered. The other attempts resulted in sediment recoveries of 36 to 43 cm, without exception consisting of foraminiferal nannofossil oozes. The board analyses revealed to some extent Mn-enrichments in oxidic surface layers (up to 0.48 %) but no conclusive hydrothermal impact could be stated. The $CaCO_3$-concentrations (74.3 - 81.5 %) are on average about 15 % higher compared to the eastern section of the GR (85°16' - 90°50'W). In contrary SiO_2-values are on average 15 % lower along the western section (12.2 - 16.6 % SiO_2). This observation may either be explained by the greater distance of the western section in respect to the silica skeletons producing equatorial zone or by the greater distance to a terrigeneous input (clay minerals). Conclusive results will be obtained, if further shore-based analyses are available. The thickest oxidic layer (29 cm) was observed at 85 GK, a station located 13.9 nm north of a broad rifted depression (94°28.67'W).

- Seawater sampling and STD-measurements

Only one hydrographic station was placed within this section: 87 MS+H at 2°37.81'N/ 95°05.32'W, located at the eastern border of the De Steiguer Deep. Data obtained in the deep water column (2,631 - 3,025 m) revealed no hydrothermal impact.

- Rocks

Volcanic glass fragments with thin Mn/Fe-coatings were recovered at 75 GK (93°16'W); a chain dredge was lost during 93 D (94°16'W).

- Visual observations and hydrothermal indications

Outside the area investigated in detail (94°46' - 95°05'W, chapter 12.7) 9 photo-profiles were placed along and crossing the zero-age axis:
152 FSO at 91°36'W, 153 FSO at 91°57'W, 96 FSO at 92°52'W, 95 and 154 FSO at 93°40'W, 155 FSO at 93°43'W, 157 FSO at 93°45'W, 86 FSO at 94°32'W and 88 FSO at 95°07'W (De Steiguer Deep, eastern part). The observations revealed no hydrothermal impact of substantial extent. Although prerequisites of hydrothermal

convection, highly fluid lavas (SS, SC-type) with thin sediment cover and swarms of fissures and gjas were observed at several locations no hydrothermal products pointing to deep water circulation were found. Indications of a very weak impact are listed below:

86 FSO	94°32'W	23.20 h	HSF = very weak smectitic coatings on talus fragments
153 FSO	91°57'W	4.10-6.01 h	HP = olive-green (nontronitic?) dusting on ponded and pillow lava surfaces (axial volcano with caldera)
154 FSO	93°40'W	21.35, 21.59 h	HC = Mn-crusts on rock surfaces.

TAB. 12.6.1: BATHYMETRIC MAPS 90°30'W - 95°30'W

		LONGITUDE/LATITUDE	SCALE	CONTOUR INTERVAL
7.	a)	W 90°35' - 90°55' N 1°40' - 2°00'	1 : 50.000	20 m
	b)	W 90°35' - 90°55' N 1°17' - 1°40'	"	"
	c)	W 90°35' - 90°55' N 0°55' - 1°17'		
8.		W 90°30' - 91°21' N 1°45' - 1°59'	"	"
9.		W 91°05' - 91°40' N 1°51' - 2°05'	"	"
10.		W 91°35' - 92°25' N 2°00' - 2°14'	"	"
11.		W 92°15' - 93°10' N 2°06' - 2°20'	"	"
12.		W 93°00' - 93°40' N 2°16' - 2°30'	"	"
13.		W 93°35' - 94°30' N 2°25' - 2°39'	"	"
14.		W 94°25' - 95°05' N 2°30' - 2°44'	"	"
15.		W 95°04' - 95°33' N 2°32' - 2°48'	"	"
16.		W 93°35' - 93°51' N 2°26' - 2°32'	1 : 20.000	10 m
17.		W 94°30' - 94°46' N 2°32' - 2°38'	"	"

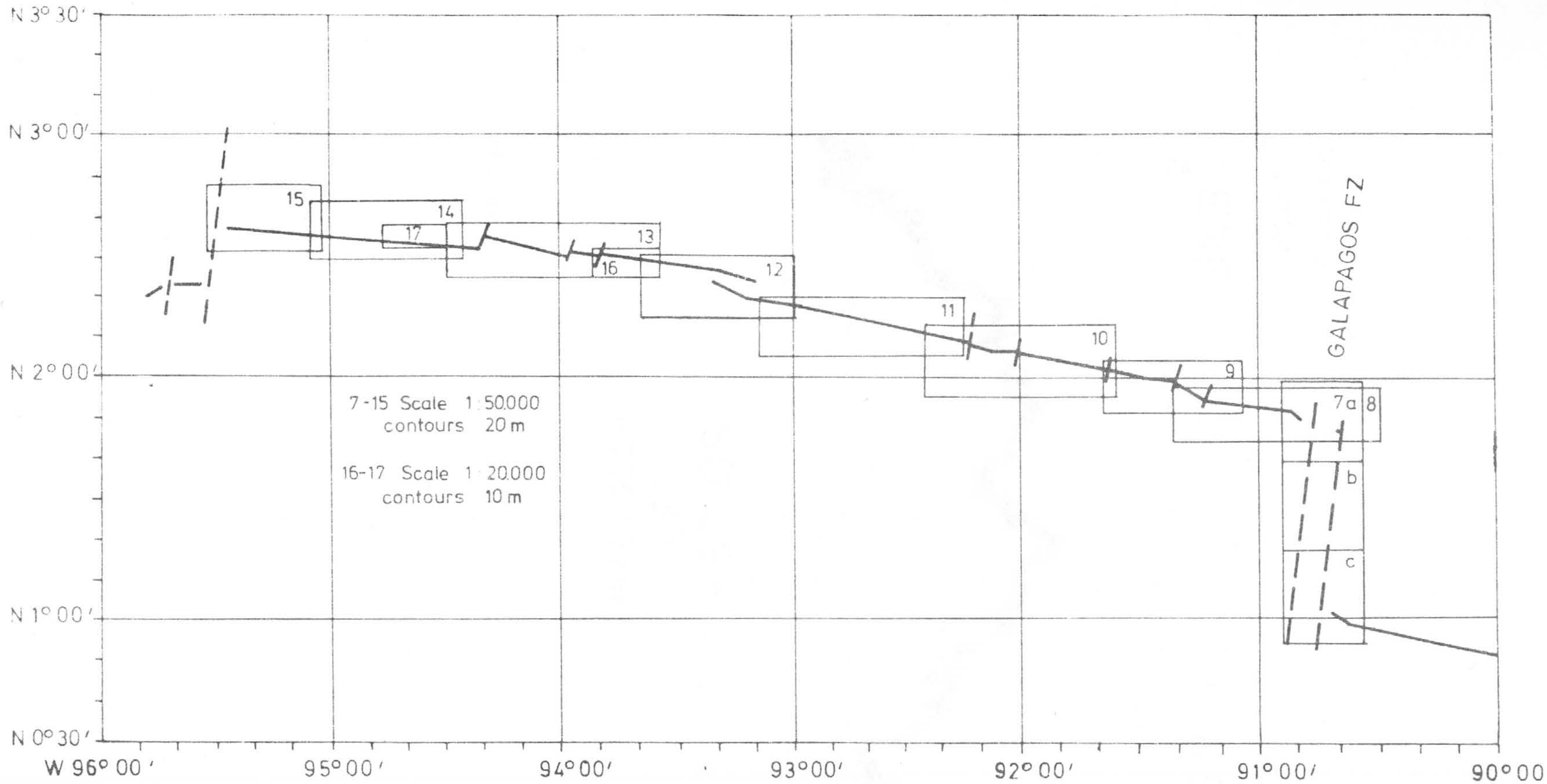


Fig. : 12.6.1. : SO-39 batymetric maps: W 90° 30' - 95° 30'

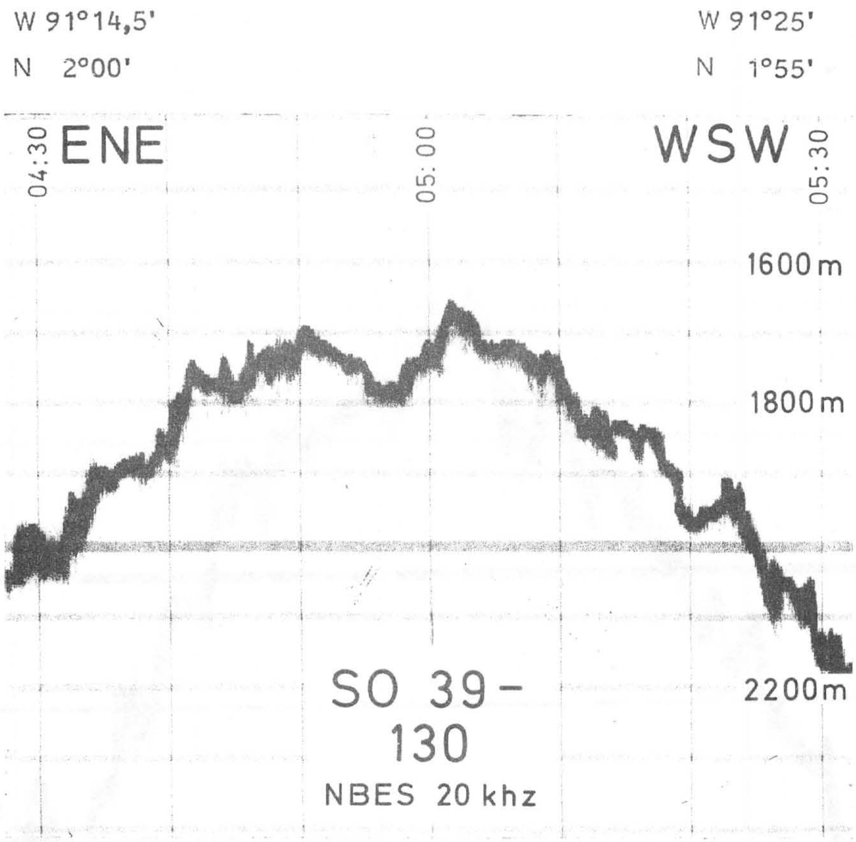

W 91°14,5'
N 2°00'
W 91°25'
N 1°55'
04:30
ENE
05:00
WSW
05:30
1600 m
1800 m
2200 m
SO 39-
130
NBES 20 khz

FIG. 12.6.2

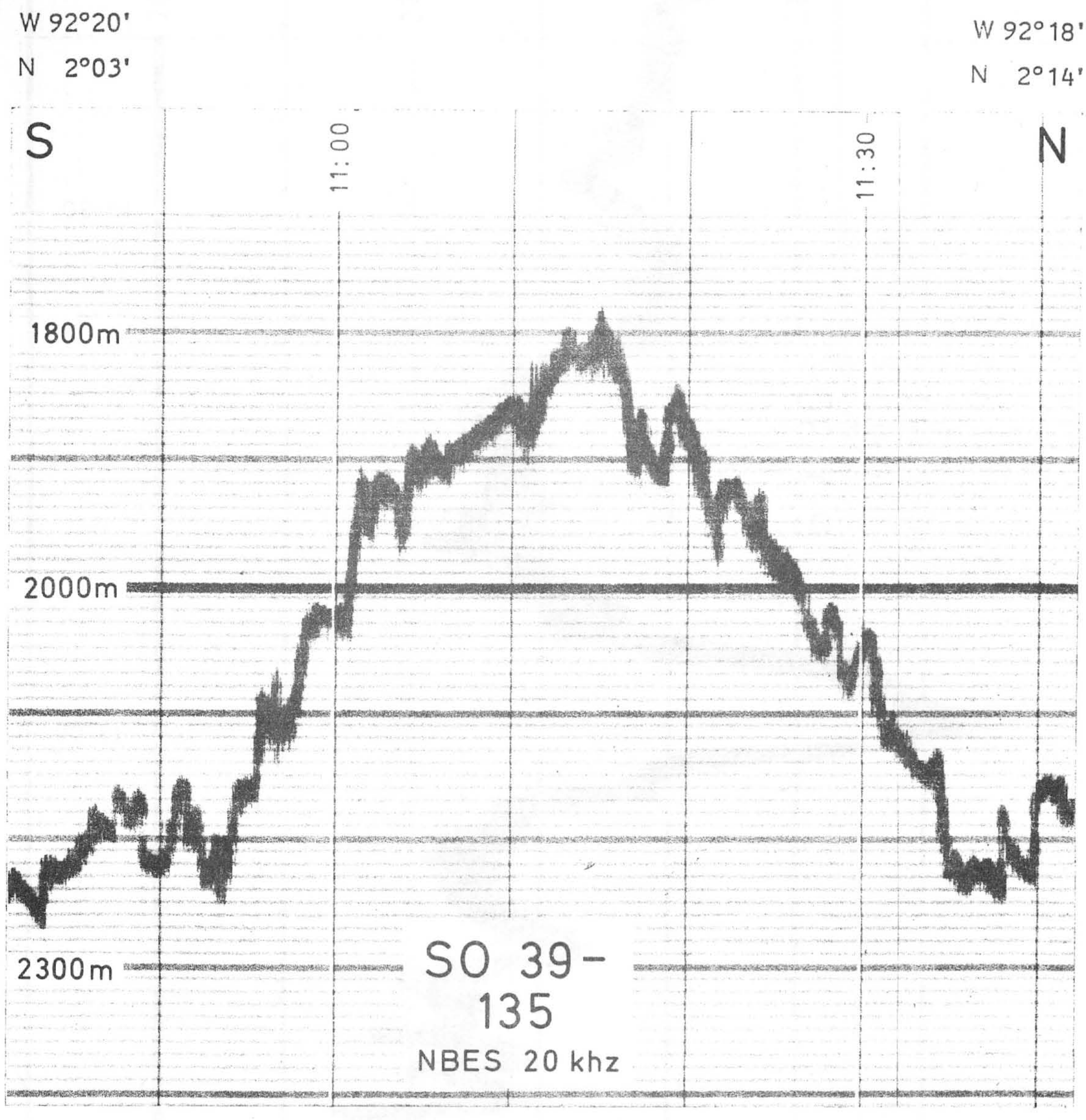

W 92°20'
N 2°03'
W 92°18'
N 2°14'
S
11:00
11:30
N
1800m
2000m
2300m
SO 39-
135
NBES 20 khz

FIG. 12.6.3

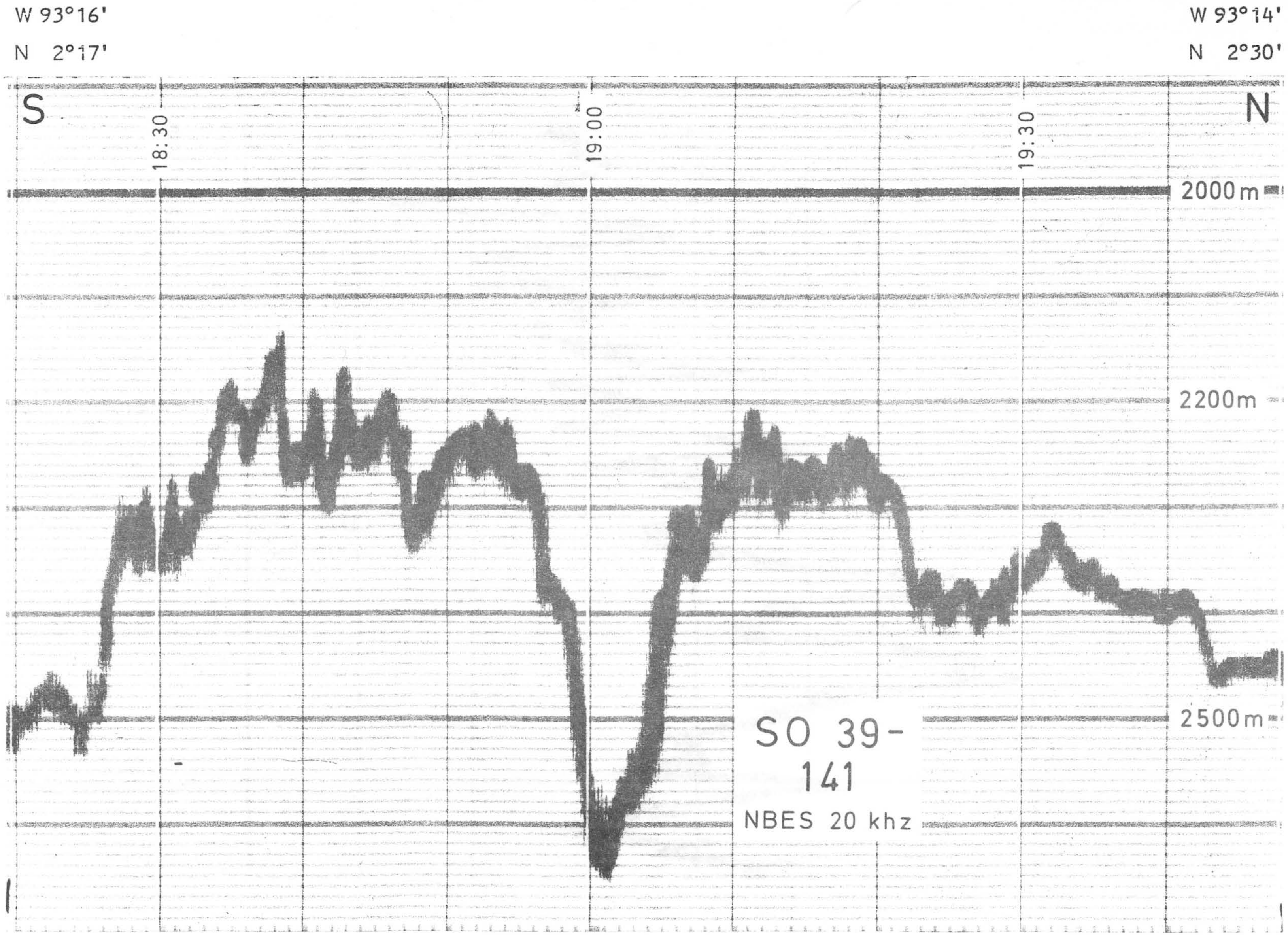

W 93°16'
N 2°17'
W 93°14'
N 2°30'
S
N
18:30
19:00
19:30
2000m
2200m
2500m
SO 39-
141
NBES 20 khz

FIG. 12.6.4

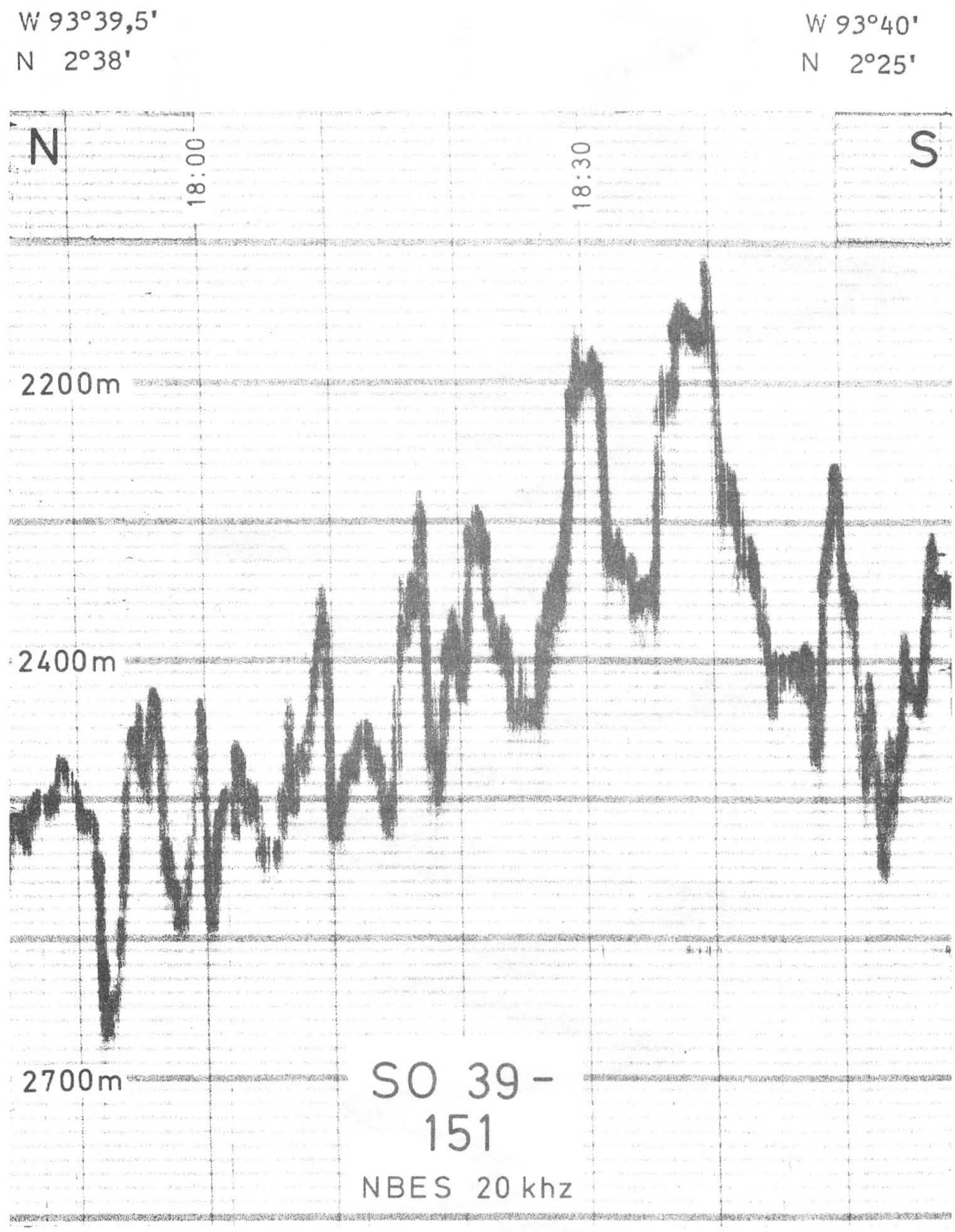

W 93°39,5'
N 2°38'
W 93°40'
N 2°25'
N
S
18:00
18:30
2200m
2400m
2700m
SO 39-
151
NBES 20 khz

FIG. 12.6.5

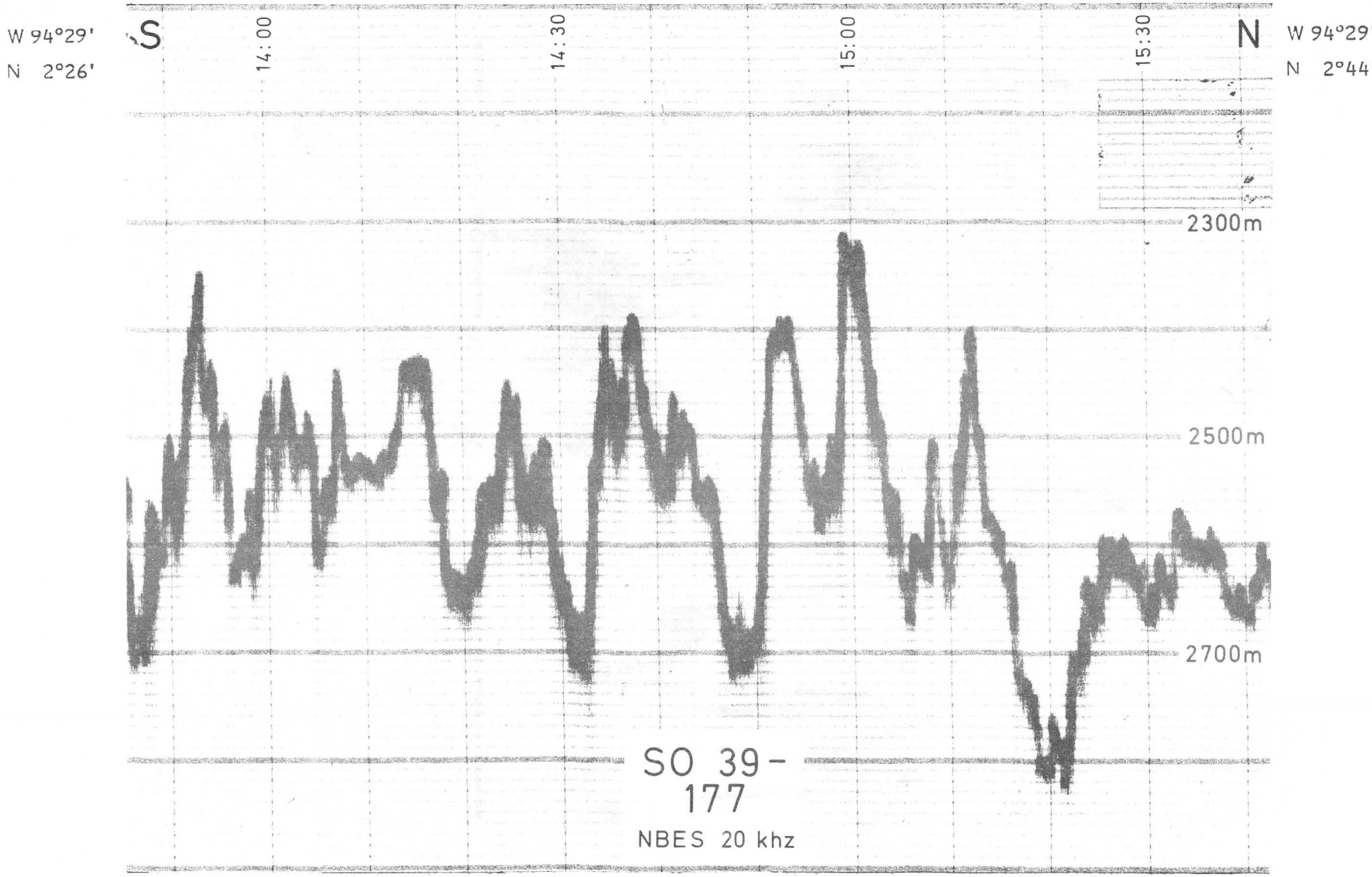

W 94°29'
N 2°26'
S
14:00
14:30
15:00
15:30
N
W 94°29'
N 2°44'
2300m
2500m
2700m
SO 39-
177
NBES 20 khz

FIG. 12.6.6

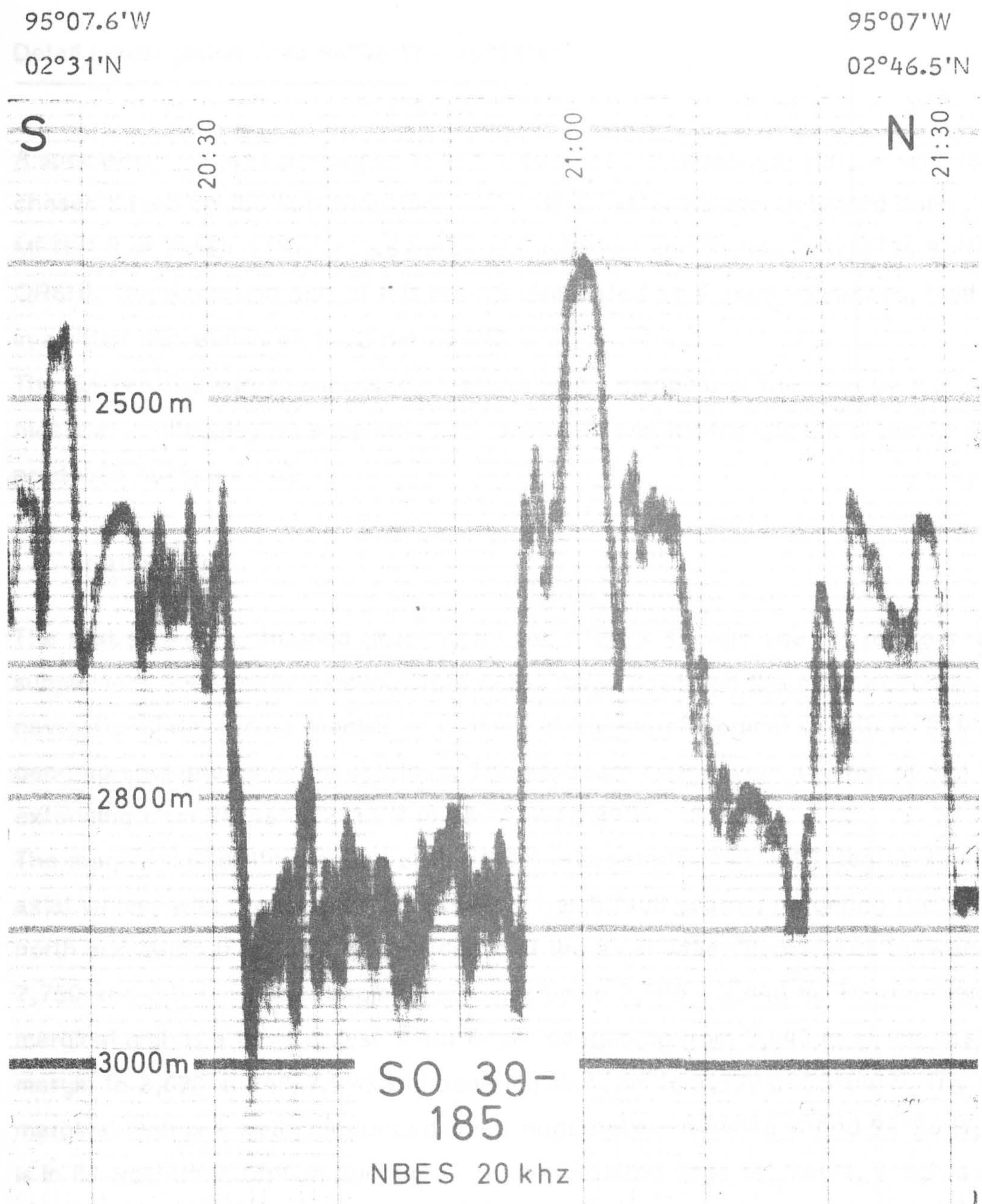

95°07.6'W
02°31'N
95°07'W
02°46.5'N
S
N
20:30
21:00
21:30
2500 m
2800 m
3000 m
SO 39-
185
NBES 20 khz

FIG. 12.6.7

12.7 Detail Investigation Area 94°46'W - 95°05'W

A special survey was performed in this section of the Galapagos Rift, which was chosen based on the Mn-anomalies in the deep water column detected during GEOMETEP 3 at 94°54.07'W/2°37.57'N (SO26 - OR5H) and 94°48.31'W/2°34.93'N (SO26-OR6H). The accretion axis of this area is dominated by 6 axial volcanoes, built up in a rifted depression of 1 - 2 nm width.

The GARIMAS 2 survey focussed on a first visual mapping of the area by photo-profiles and additionally on supplementary seabeam profiles filling gaps in the GARIMAS 1 produced seabeam map.

- Bathymetry

The seabeam data obtained (track chart see ANNEX 5) were used to revise and supplement the already existing GARIMAS 1 map. Based on the more accurate GPS-navigation data a more precise positioning of the morphological structures in the geographical grid could be obtained. The seabeam map covers an area of 391 km^2, extending from 94°46'W/2°33'N to 95°05'W/2°39'N.

The morphology of this section of the GR is characterized by a 95 degree striking axial valley, with pronounced up to 360 m heigh fault scarps, bordering the valley north and south (Fig. 12.7.1). The depth of the axial valley floor varies between 2,750 and 2,920 m, the marginal highs rise up to 2,700 - 2,440 m. The northern marginal high is a more or less linear ridge, deepening from 2,440 m at the eastern margin to 2,670 at 94°57.5'W and again climbing up to 2,570 at 95°04'W. The southern marginal high is a well pronounced linear ridge between 94°46'W and 94°56'W, but is in its western extention built up by several isolated ridge segments, which do not follow a linear striking trend. The width of the axial valley increases from about 1 nm at 94°47'W to 2.5 nm at 95°05'W, already indicating the submergence into the De Steiguer Deep. Several axial volcanoes have been built up at the zero-axis: the highest at 94°50.9'W is rising up to 2,560 m (Fig. 12.7.2), others were localized at 94°54.3'W (2,650 m), at 94°55.1'W (2,650 m) at 94°55.7'W (2,670 m, Fig. 12.7.3) and 94°58.7'W (2,700 m). The most impressive is built up from 95°01.1'W to 95°02.1'W, rising up to 2,570 m, with its top more than 300 m above the rift valley floor (Fig. 12.7.4). The summit region of this volcano is characterized by a large caldera structure at the western margin, a sub-caldera in the centre and a cinder cone at the SE-rim.

Some volcano structures were also observed slightly south of the zero-axis, but still located within the rift valley (94°56.4'W and 94°58.7'W).

. Rocks

Four dredge stations were placed in this area but all within the axial valley. The basalts recovered consisting of massive ponded lava flows with coatings of yellowish-white smectites and reddish-brown Fe-Mn-oxyhydroxides on joint planes and contraction cracks (80 D, 82 D, 90 D). One station (91 D), located in a northern marginal depression of the rift valley at 94°59.2'W revealed massive ponded lava with a porphyric matrix, containing plagioclase and olivine phenocrysts of mm-size. In addition, fragments of curtain fold/ropy sheet lava were sampled at this site. The station is located within the area where turbid water masses were observed during photo-profile 92 FSO.

. Sediments

No attempts to recover sediments were performed.

. Water sampling and STD-measurements

No stations.

. Visual observations and hydrothermal indications

Seven photo profiles were run in this area between 94°49' and 95°00'W, covering the main structures of the rift system: the northern marginal high at 94°49'W (78 FSO), the central axial volcanoes at 94°55.1'W (81 FSO), and 94°58.6'W (83 FSO), the zero-axis and northern margins of the axial valley (92 FSO at 94°59.5'W, 94 FSO at 94°59'W and 156 FSO at 94°58.5'W) and the southern marginal high (89 FSO at 94°52'W). No indications were found on profiles 78 FSO and 89 FSO, mainly covering the marginal highs, their inward facing slopes and the base of these slopes. All other profiles revealed indications of a very weak and low-temperature hydrothermal activity, mainly resulting in light green to pistache green sediment and lava dustings by Fe-smectites (nontronites?). During 92 FSO indications of turbid water pointed to a recent activity of this low temperature hydrothermal cycle. The centre is located in a marginal depression of the rift valley at the base of the northern marginal high (Fig. 12.7.5). For about 12 min (21.55 - 22.07 h) several photos were taken, exhibiting weak to slightly turbid water masses in 2,834 to 2,867 m water depth (94°58.67'W/2°37.56'N-94°58.64'W/2°37.47'N).

Reinvestigation of this location during profiles 94 and 156 FSO did not confirm the turbid water flows. It may be concluded that the activity is intermittent or periodical. The axial volcanoes investigated show a relative fresh appearance of SN/SL-lava flows in the summit region with only limited sediment coverage (3 - 20 %). Indications of hydrothermalism are summarized below:

81 FSO	94°55'W	2.24 - 3.42 h 5.12 - 5.37 h	HM =	sediment colouration, pistache green (nontronitic?) and
			HP =	pistache green precipitates on joint planes
		2.29 - 2.47 h 4.34 h	HFC =	galatheas along cracks between lava cushions
83 FSO	94°58'W	2.18 - 2.38 h 4.37, 6.00-6.05 h	HP =	pistache green precipitates (nontronite?) in lava cracks
		4.32 - 4.38 h	HM =	pistache green sediment colouration (nontronites?)
		4.55 h	HSF=	ponded lava with smectitic precipitates on joint planes
92 FSO	94°59.5'W	20.13 - 20.24 h	HP =	pistache green precipitates (nontronites?) along cracks between lava cushions
		21.55 - 22.07 h	HO =	water turbidity; active hydrothermal field?
94 FSO	94°59'W	02.28 - 02.34 h	HSF =	smectite and Fe-oxyhydroxide coatings on talus fragments
156 FSO	94°58.5'W	19.08, 19.47 h 20.05 h	HSF =	smectitic and Fe-oxyhydroxidic coatings on talus fragments.

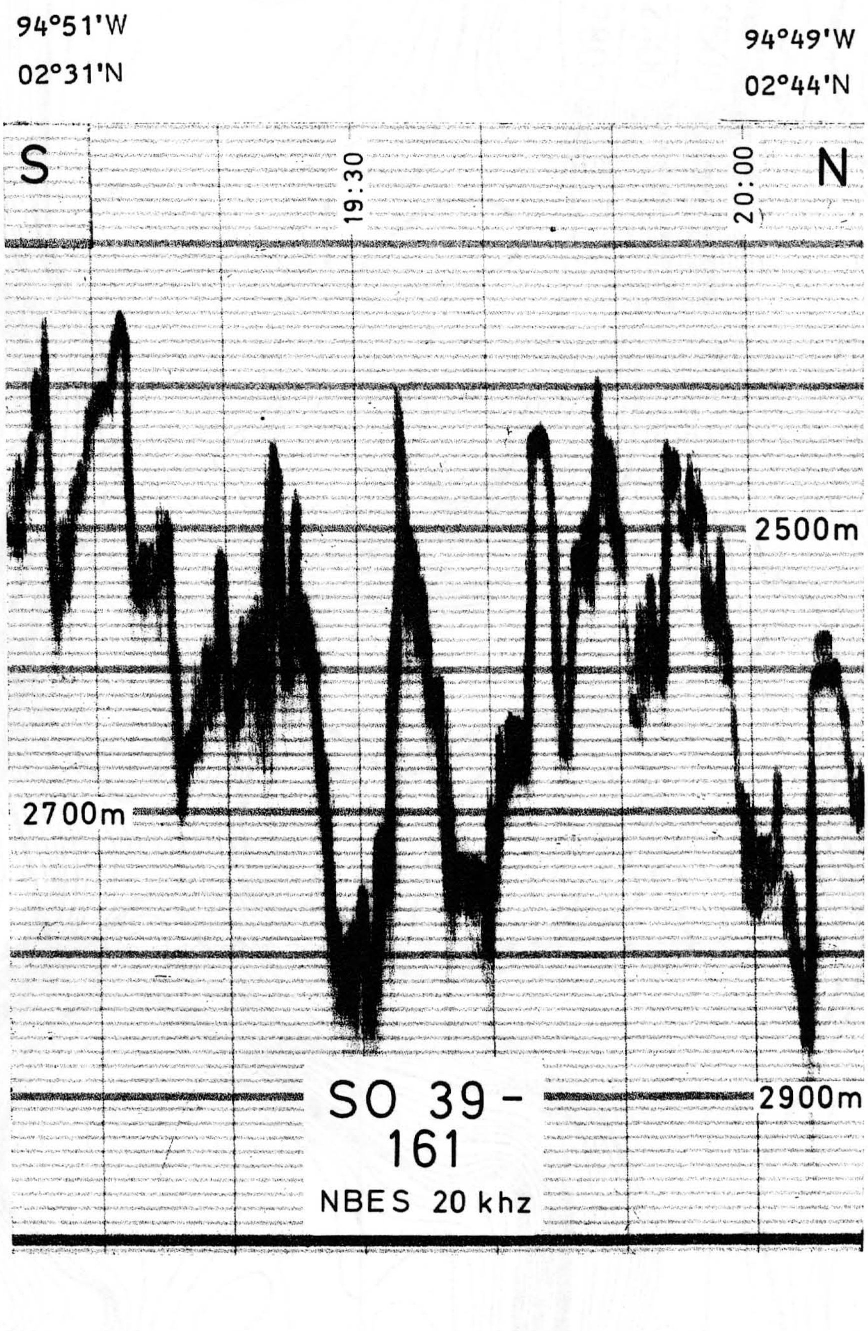


FIG. 12.7.1: BATHYMETRIC CROSS SECTION AT 94°50'W

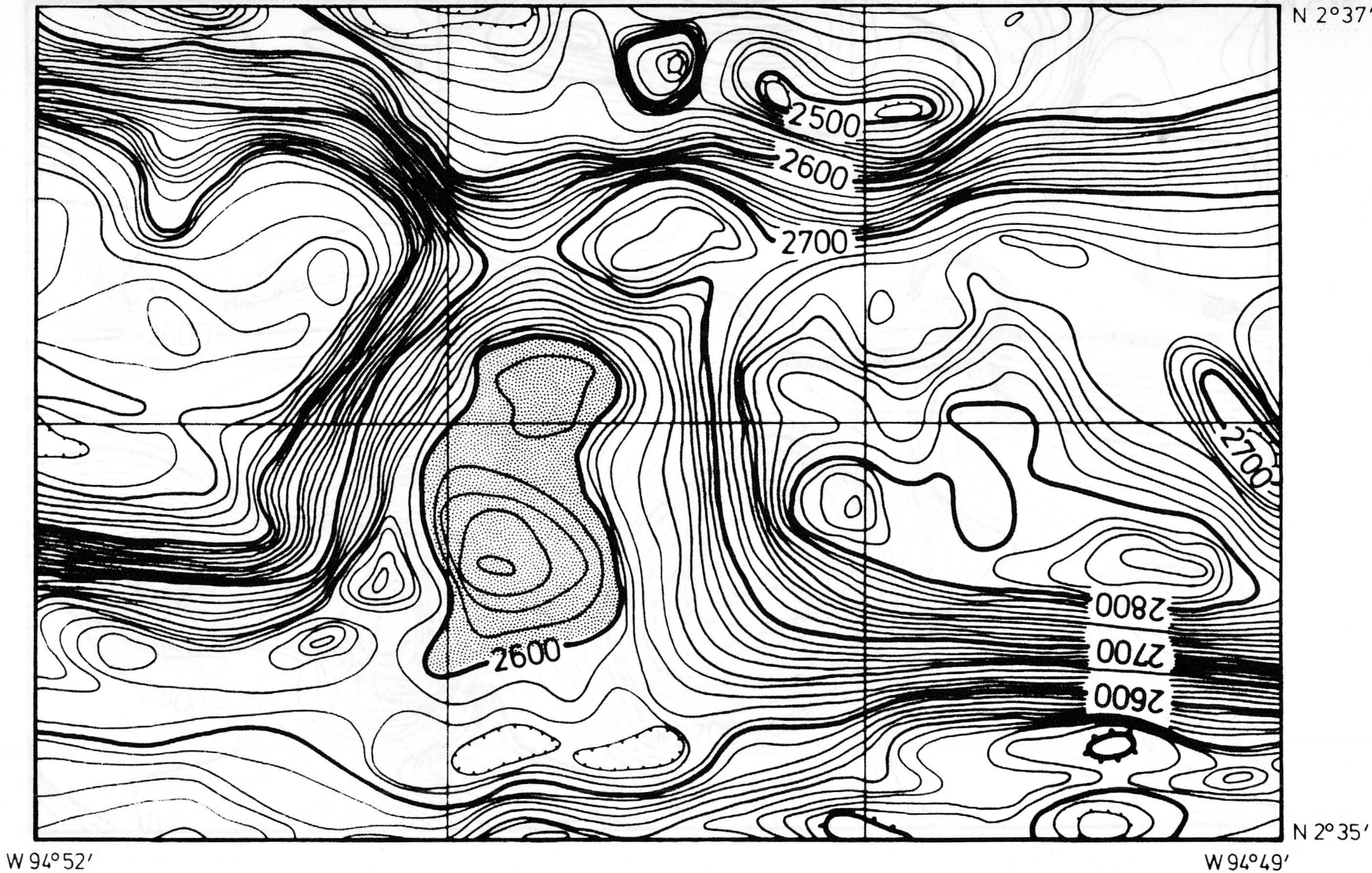


FIG. 12.7.2: AXIAL SEAMOUNT AT 94°50.9'W

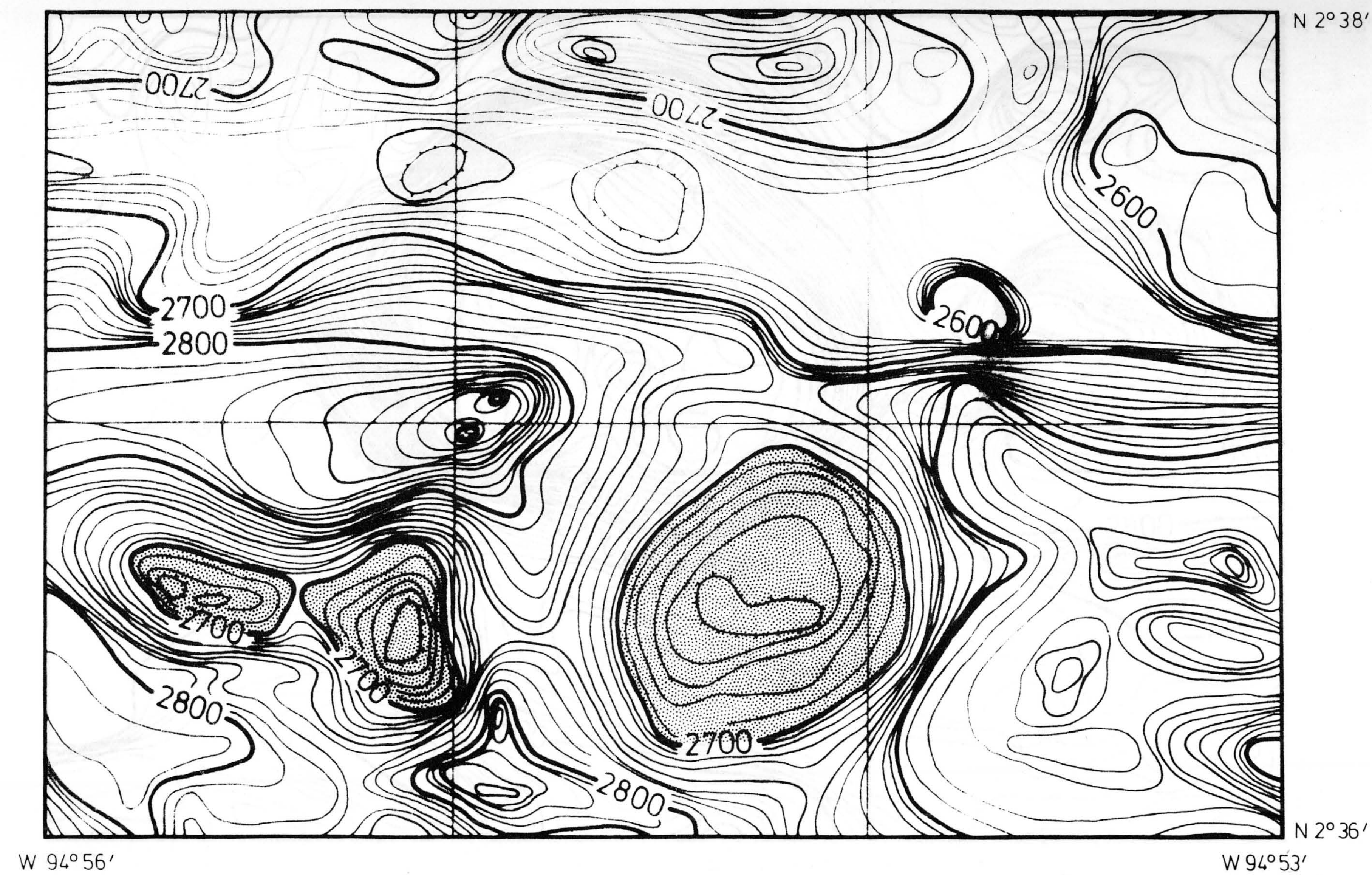


FIG. 12.7.3: TRIO OF AXIAL SEAMOUNTS AT 94°55'W

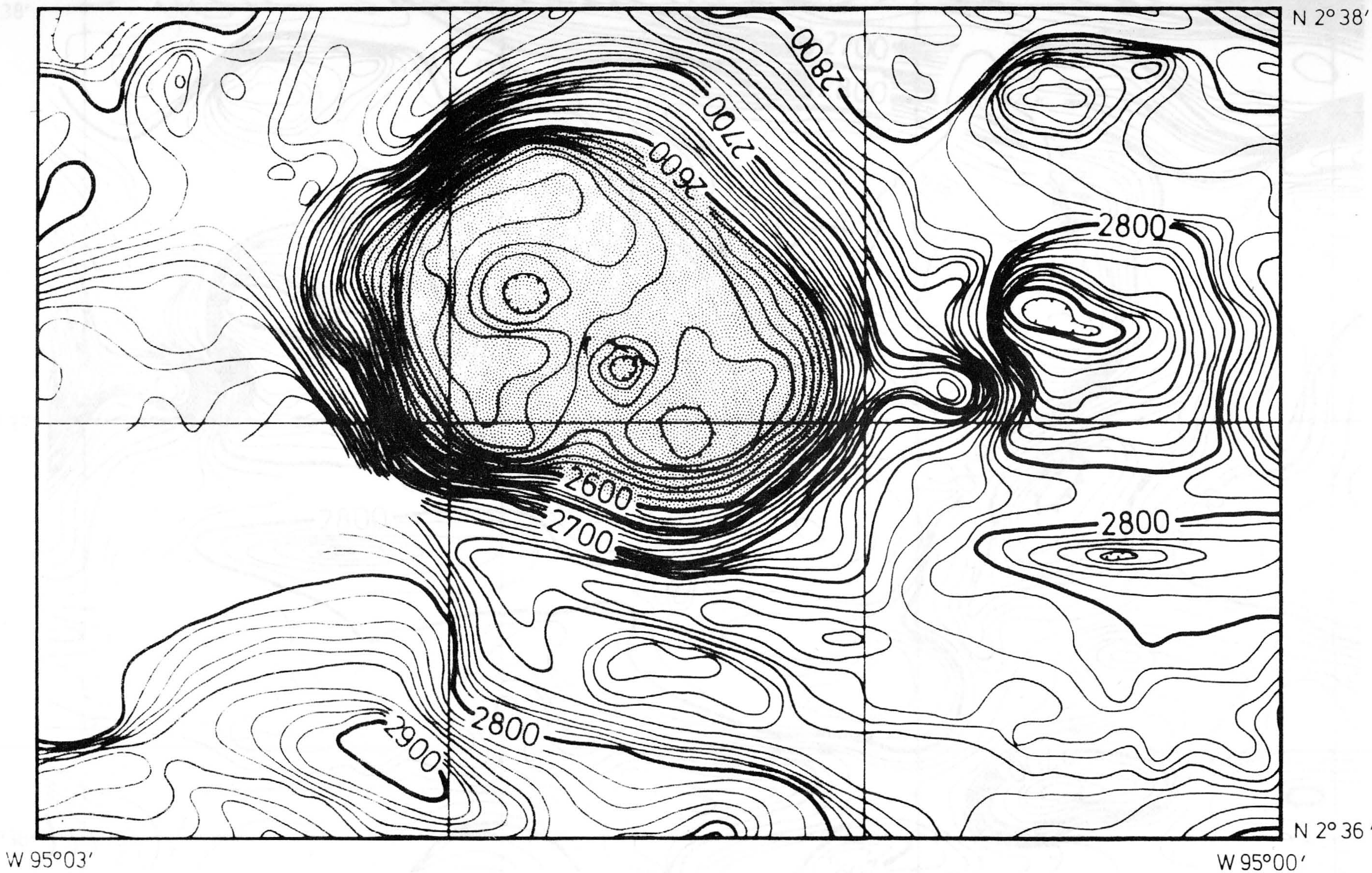


FIG. 12.7.4: AXIAL SEAMOUNT WITH SUMMIT CALDERA

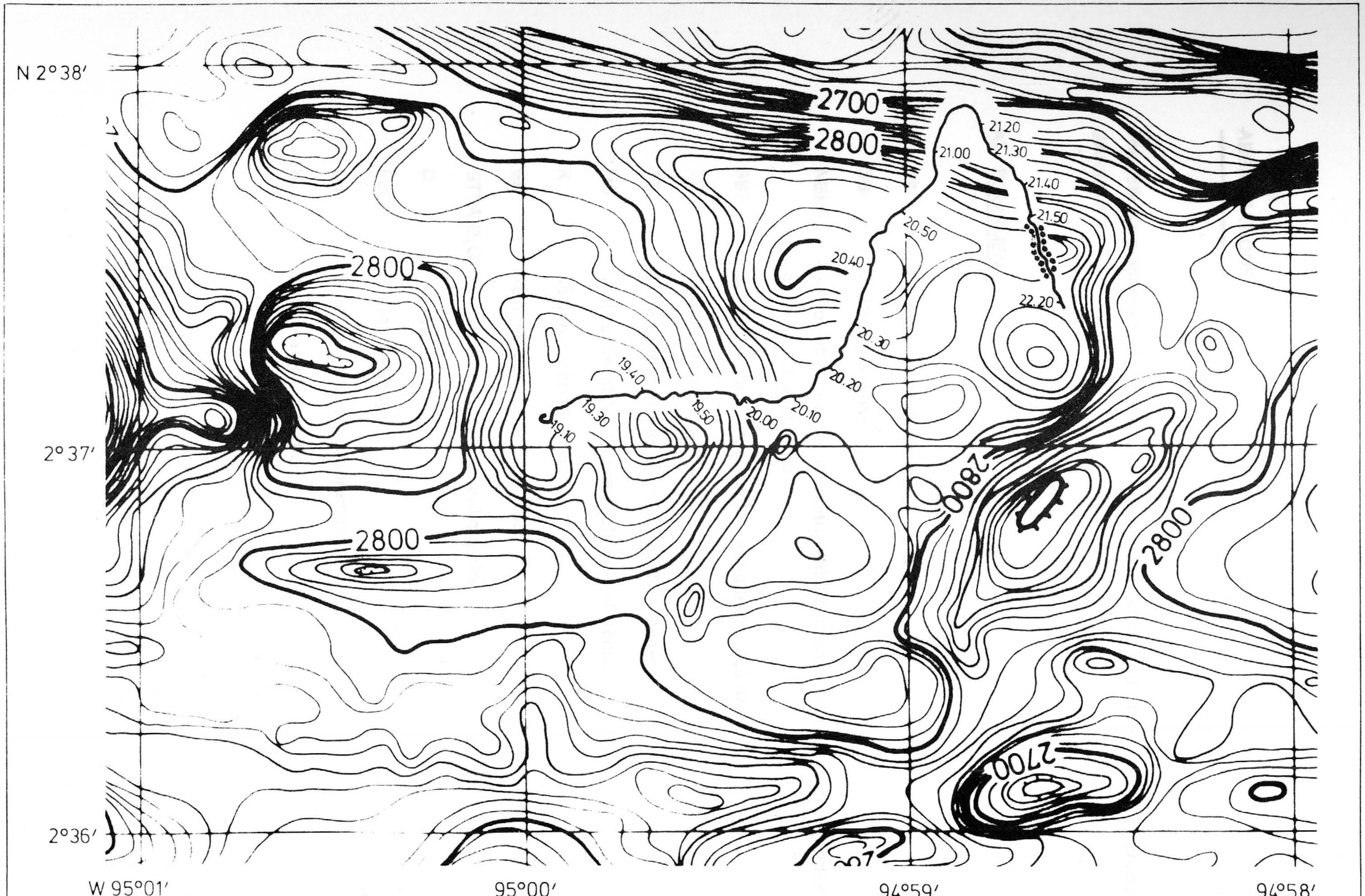


FIG. 12.7.5: TRACK OF PHOTO PROFILE 92 FSO

13. ABBREVIATIONS

The following abbreviations are used in this cruise report and other reports of cruise GARIMAS 2.

A) EQUIPMENT

FS	Forschungsschiff, research vessel
SB	Seabeam System
NBES	Narrow-beam echo sounder. Stabilized echo sounder "Schelfrandlot" of ELAC, 20 and 30 kHz
SBP	Subbottom profiler, sediment echograph, 3,5 kHz
TB	Bottom pinger, 16 kHz
TT	Transponder of the Atnav navigation system
MS	Multisonde of ME Meerestechnik-Elektronik
K	Kasten corer 15 cm (box corer)
GK	Reineck box corer (box grab)
GTVA,B,C	TV-guided electro-hydraulic grabs
D	Dredge
FSO	Photo TV-sledge
CS	Eulerian current measurement
H	Water sampling station

B) SEAFLOOR FORMATIONS

VOLCANITES

L	=	Lava, not determined
P	=	Pillow lava, not determined
PL	=	Pillows, striated
PP	=	Pillows with protuberances
PI	=	Individual pillows in sediment covered area
PLS	=	Pillow and sheet lava
S	=	Sheet lava, not determined
SL	=	Lobated sheet lava
SN	=	Nodular sheet lava
SP	=	Platy sheet lava
SC	=	Curtain fold/ropy sheet lava
SS	=	Scrambled sheet lava
T	=	Talus
TP	=	Pillow talus
TS	=	Sheet lava talus
B	=	Breccia/brecciated volcanites

SEDIMENT

M0	=	No sediment; reflection at glass surfaces		
M1	=	Sediment dusting; sediment in interstitial spaces		
M2	=	Sediment cover in part;	P	: < 30 %
			SL,SN,SS	: < 50 %
			SP, SC	: < 100 %
M3	=	Strong sediment cover	P	: > 30 %
			SL,SN,SS	: > 50 %
M4	=	Total sediment cover; no rock outcrops		

TECTONIC STRUCTURES

GC	=	Crack/small fissure
G	=	Fissure/gja
G, w, o	=	Fissure/gja, width (m), offset (m), (up + down -): G, 2,-4
GF	=	Flat floored fissure
GF, w, o	=	Flat floored fissure, width (m), offset (m) (up + down -): GF,5,+2
D	=	Displacement without fissure/crack
Do	=	Displacement with offset (< 3m) in m (up + down -):D+2
DA	=	Displacement assumed
DS	=	Scarp
DSo	=	Scarp with offset (> 3m) in m (up + down -): DS-10
DSA	=	Scarp assumed

COLLAPSE STRUCTURES

CS	=	Collapse structure (small scale)
CP	=	Collapse structure (large scale); collapse pits, lava lakes

MORPHOLOGY

FF	=	Flow front
+-	=	Flat terrain
++	=	Slope upwards
--	=	Slope downwards

HYDROTHERMALISM

H	=	General indications
HH	=	Sulphides
HHH	=	Sulphides, large area
HP	=	Precipitates on cracks and volcanite surfaces
HSF	=	Silicate and ferronian precipitates on cracks
HF	=	Fauna
HFC	=	Crab
HFP	=	Pogonophora
HF, C, x	=	Special fauna (x)
HM	=	Sediment coloration; oxyhydroxides
HML	=	Light coloration
HMD	=	Strong coloration
HC	=	Crusts/oxyhydroxides
HA	=	Halo around rocks

FAUNA

FB	=	Benthos; sessil + vagrant
FE	=	Endobenthos/ichnofossils

COMMENTS

C, xyz	=	General comment (sub-position, distance ship-equipment, number of flashes and lights, number of photos, morphological and tectonical features, statements to function of TV-grab, etc.)
TON	=	Tape on
TOF	=	Tape off
BOT1	=	First bottom sight
BOP1	=	First bottom photo
LOB	=	Loss of bottom sight
BOT	=	Bottom sight again
UP	=	Heaving start
SAM, x	=	Sampling
RCON	=	Colour TV, record on
RCOF	=	Colour TV, record off
RBON	=	Black and white TV, record on
RBOF	=	Black and white TV, record off

14. STATION LISTS

S T A T I O N - L I S T

GARIMAS 2 (all Stations)

STATION NO.		LATITUDE DEG	MIN	LONGITUDE DEG	MIN	DEPTH M	SUB-POSITION	RECOVERY
1	CTVC	N 2	23.00	W 84	27.00	3080	-	1800
2	MS+H	N 0	46.215	W 85	54.674	2575	-	-
3	CS	N 0	45.53	W 85	53.82	2520	-	-
4	MS+H	N 0	46.212	W 85	56.032	2539	-	-
5	MS+H	N 0	45.721	W 85	52.789	2626	-	-
6	CTVC	N 0	46.169	W 85	54.933	2578	-	400
7	GTVC	N 0	46.138	W 85	53.738	2616	-	-
8	MS+H	N 0	47.701	W 86	03.920	2505	-	-
9	MS+H	N 0	46.132	W 86	00.403	2493	-	-
10	D	N 0	45.231	W 85	49.431	2659	-	150
11	GTVC	N 0	45.939	W 85	54.753	2580	-	250
12	GTVC	N 0	46.117	W 85	53.901	2475	-	1200
13	MS+H	N 0	46.467	W 85	58.169	2590	-	-
14	GK	N 0	47.023	W 85	28.212	2875	-	12
15	CK	N 0	40.866	W 85	28.583	2775	-	30
16	CTVC	N 0	46.017	W 85	55.236	2566	-	20
17	GTVC	N 0	46.034	W 85	55.119	2572	-	-
18	MS+H	N 0	48.858	W 86	12.628	2471	-	-
19	MS+H	N 0	49.014	W 86	17.036	2448	-	-
20	GTVC	N 0	46.145	W 85	55.254	2576	-	-
21	GTVC	N 0	46.125	W 85	55.238	2584	-	1
22	GK	N 0	53.197	W 86	10.156	2710	-	17
23	CK	N 0	45.529	W 86	14.000	2880	-	0.6 kg
24	D	N 0	49.117	W 86	13.080	2495	-	28
25	GTVB	N 0	46.096	W 85	55.016	2581	-	-
26	D	N 0	46.097	W 85	55.031	2573	-	280
27	GTVA	N 0	45.985	W 85	55.011	2573	-	-
28	D	N 0	46.161	W 85	55.290	2583	-	25
29	D	N 0	46.014	W 85	55.227	2566	-	400
30	GTVB	N 0	43.122	W 85	50.335	2635	-	80
31	MS+H	N 0	45.496	W 85	44.477	2685	-	-
32	D	N 0	45.954	W 85	54.786	2584	-	333
33	GTVB	N 0	45.020	W 85	50.607	2606	-	100
34	CTVB	N 0	44.982	W 85	50.468	2554	-	180
35	GTVA	N 0	45.984	W 85	54.675	2559	-	5
36	GTVA	N 0	46.018	W 85	54.703	2555	-	-
37	GTVA	N 0	45.989	W 85	54.692	2574	-	32
38	GTVC	N 0	45.984	W 85	54.620	2577	-	2
39	GTVC	N 0	45.102	W 85	50.621	2597	-	235
40	GTVC	N 0	45.985	W 85	54.617	2577	-	50
41	GTVC	N 0	46.006	W 85	54.645	2574	-	1037
42	CTVC	N 0	45.990	W 85	54.628	2573	-	70
43	GTVB	N 0	44.980	W 85	50.271	2606	-	170
44	GK	N 0	41.895	W 86	07.304	2745	-	40
45	GK	N 0	55.077	W 86	08.179	2674	-	42
46	D	N 0	45.1	W 85	49.7	2581	-	15
47	GTVC	N 0	44.984	W 85	50.701	2612	-	50
48	D	N 0	45.141	W 85	48.823	2635	-	760
49	MS+H	N 0	45.173	W 85	48.058	2642	-	-
50	CTVC	N 0	46.015	W 85	54.640	2574	-	997
51	GTVA	N 0	45.987	W 85	54.633	2559	-	60

S T A T I O N - L I S T continued

GARIMAS 2 (all Stations)

STATION NO.	LATITUDE DEG	LATITUDE MIN	LONGITUDE DEG	LONGITUDE MIN	DEPTH M	SUB-POSITION	RECOVERY
52 GTVC	N 0	45.995	W 85	54.636	2559	-	600
53 GTVC	N 0	45.991	W 85	54.640	2562	-	600
54 MS+H	N 0	45.260	W 85	49.786	2626	-	-
55 GTVC	N 0	45.984	W 85	54.713	2559	-	300
56 GTVC	N 0	45.993	W 85	54.670	2555	-	131
57 GTVC	N		W		2606	-	-
58 D	N 0	45.998	W 85	54.737	2574	-	360
59 D	N 0	45.988	W 85	54.723	2580	-	600
60 GTVC	N 0	45.959	W 85	54.753	2570	-	400
61 GTVC	N 0	45.000	W 85	50.490	2599	-	759
62 MS+H	N 0	47.2	W 86	02.2	2544	-	-
63 GTVC	N 0	46.060	W 85	54.631	2573	-	300
64 GTVC	N 0	45.962	W 85	54.781	2574	-	-
65 GTVC	N 0	46.000	W 85	54.870	2578	-	1109
66 GTVA	N 0	46.254	W 85	55.523	2609	-	-
67 D	N 0	45.997	W 85	54.911	2558	-	400
68 GTVA	N 0	46.197	W 85	55.606	2610	-	256
69 D	N 0	45.073	W 85	50.585	2572	-	1300
70 MS+H	N 0	45.073	W 85	42.031	2689	-	-
71 GK	N 0	58.528	W 86	58.848	2620	-	40
72 GK	N 0	37.642	W 87	08.290	2704	-	33
73 GK	N 0	45.196	W 87	38.765	2335	-	16
74 GK	N 2	29.914	W 93	14.064	2445	-	40
75 GK	N 2	22.697	W 93	15.842	2613	-	3
76 FSO (S)	N 2	24.906	W 93	16.619	2272	-	76
(E)	N 2	25.555	W 93	15.710	2249	-	
77 GK	N 2	16.831	W 93	17.080	2493	-	42
78 FSO (S)	N 2	37.059	W 94	49.001	2563	-	246
(E)	N 2	35.691	W 94	48.804	2835	-	
79 D	N 2	36.389	W 94	49.347	2678	-	-
80 D	N 2	36.401	W 94	49.388	2699	-	400
81 FSO (S)	N 2	36.558	W 94	55.634	2725	-	451
(E)	N 2	36.991	W 94	54.580	2792	-	
82 D	N 2	35.871	W 94	53.400	2763	-	500
83 FSO (S)	N 2	36.907	W 94	58.494	2678	-	755
(E)	N 2	36.852	W 94	56.986	2802	-	
84 GK	N 2	22.724	W 94	28.442	2576	-	40
85 GK	N 2	40.479	W 94	28.674	2764	-	36
86 FSO (S)	N 2	34.453	W 94	32.100	2432	-	330
(E)	N 2	33.550	W 94	31.550	2599	-	
87 MS+H	N 2	37.810	W 95	05.317	2986	-	-
88 FSO (S)	N 2	40.057	W 95	07.063	2420	-	432
(E)	N 2	36.675	W 95	07.566	2875	-	
89 FSO (S)	N 2	34.595	W 94	52.070	2448	-	424
(E)	N 2	36.768	W 94	52.408	2792	-	
90 D	N 2	35.605	W 94	47.953	2807	-	130
91 D	N 2	37.382	W 94	59.132	2878	-	1200
92 FSO (S)	N 2	37.070	W 94	59.947	2697	-	688
(E)	N 2	36.991	W 94	58.491	2609	-	
93 D	N 2	33.077	W 94	15.983	2513	-	-

S T A T I O N - L I S T continued

CARIMAS 2 (all Stations)

STATION NO.	LATITUDE		LONGITUDE		DEPTH	SUB-	
	DEG	MIN	DEG	MIN	M	POSITION	RECOVERY
94 FSO (S)	N 2	37.549	W 94	58.685	2817	.	573
(E)	N 2	37.533	W 94	58.699	2836	-	
95 FSO (S)	N 2	29.836	W 93	40.076	2187	-	475
(E)	N 2	29.284	W 93	38.696	2299	-	
96 FSO (S)	N 2	16.099	W 92	51.180	2039	-	214
(E)	N 2	15.130	W 92	51.066	2105	-	
97 FSO (S)	N 1	48.588	W 90	47.653	1881	-	322
(E)	N 1	48.936	W 90	49.639	2613	-	
98 GK	N 0	50.212	W 90	14.866	2200	-	0.3 kg
99 GK	N 1	00.440	W 90	12.271	2090	-	41
100 K300	N 0	37.132	W 87	09.333	2713	-	74
101 GTVC	N 0	45.977	W 85	54.529	2582	-	.
102 GTVB	N 0	46.015	W 85	54.628	2574	+	672
103 GTVC	N 0	45.973	W 85	54.667	2577	-	.
104 GTVB	N 0	46.0	W 85	54.7	2566	-	-
105 FSO (S)	N 0	45.854	W 85	54.909	2579	+	282
(E)	N 0	46.455	W 85	54.176	2540	-	
106 GTVB	N 0	46.002	W 85	54.710	2554	-	423
107 GTVB	N 0	46.018	W 85	54.635	2573	-	-
108 GTVC	N 0	45.982	W 85	54.645	2570	-	.
109 GTVB	N		W		2577	-	-
110 FSO (S)	N 0	46.004	W 85	54.533	2531	+	771
(E)	N 0	46.142	W 85	53.443	2605	+	
111 FSO (S)	N 0	42.111	W 85	28.300	2552	+	240
(E)	N 0	42.709	W 85	28.606	2603	+	
112 GTVB	N 0	45.996	W 85	54.843	2573	-	398
113 GTVB	N 0	45.996	W 85	54.672	2554	-	-
114 GTVB	N 0	46.123	W 85	53.443	2599	-	-
115 GTVB	N 0	46.04	W 85	53.33	2608	-	-
116 FSO (S)	N 0	46.214	W 85	54.157	2511	+	430
(E)	N 0	46.000	W 85	52.600	2542	+	
117 GTVB	N 0	46.000	W 85	54.593	2583	-	150
118 GTVB	N 0	45.93	W 85	54.61	2577	-	-
119 GTVA	N 0	46.011	W 85	54.656	2582	-	600
120 GTVA	N 0	45.985	W 85	54.663	2575	-	500
121 GTVA	N 0	45.969	W 85	54.688	2565	-	1791
122 GTVA	N 0	45.835	W 85	54.716	2570	-	200
123 FSO (S)	N 0	46.072	W 85	53.465	2608	+	686
(E)	N 0	46.173	W 85	53.442	2596	+	
124 GTVC	N 0	46.080	W 85	53.460	2603	-	350
125 GTVC	N 0	46.151	W 85	53.435	2606	.	10
126 GTVC	N 0	46.000	W 85	54.753	2579	-	3347
127 GTVC	N 0	45.992	W 85	54.772	2557	-	356
128 GTVC	N 0	46.023	W 85	54.744	2568	-	200
129 GTVC	N 0	45.997	W 85	54.778	2581	-	0.2
130 FSO (S)	N 0	46.052	W 85	54.882	2574	+	704
(E)	N 0	46.049	W 85	54.703	2574	+	
131 GTVC	N 0	46.033	W 85	54.860	2577	-	9 7
132 GTVC	N 0	46.07	W 85	54.57	2571	-	

S T A T I O N - L I S T continued

GARIMAS 2 (all Stations)

STATION NO.		LATITUDE DEG		MIN	LONGITUDE DEG		MIN	DEPTH M	SUB-POSITION	RECOVERY
133 FSO	(S)	N	0	46.030	W	85	54.836	2578	+	762
	(E)	N	0	46.265	W	85	53.867	2533	+	
134 GTVC		N	0	46.021	W	85	54.940	2570	-	230
135 GTVC		N	0	46.001	W	85	54.851	2584	-	350
136 GK		N	0	58.316	W	86	30.505	2771	-	39
137 FSO	(S)	N	0	36.760	W	87	09.374	2708	+	456
	(E)	N	0	38.522	W	87	08.259	2710	+	
138 GTVA		N	0	38.389	W	87	08.389	2703	-	500
139 FSO	(S)	N	0	41.701	W	87	55.784	1977	+	179
	(E)	N	0	42.159	W	87	55.692	2133	+	
140 FSO	(S)	N	0	41.277	W	87	41.935	2024	+	566
	(E)	N	0	43.402	W	87	42.059	2244	+	
141 GTVA		N			W			2707	-	400
142 FSO	(S)	N	0	41.806	W	87	23.904	2234	+	139
	(E)	N	0	41.421	W	87	23.637	2200	+	
143 FSO	(S)	N	0	44.021	W	87	10.816	2129	+	253
	(E)	N	0	43.560	W	87	10.242	2181	+	
144 FSO	(S)	N	0	49.790	W	86	29.778	2337	+	320
	(E)	N	0	50.597	W	86	28.939	2321	+	
145 FSO	(S)	N	0	49.016	W	86	25.506	2430	+	770
	(E)	N	0	47.855	W	86	26.249	2437	+	
146 GTVC		N	0	45.983	W	85	54.782	2589	-	80
147 GTVC		N			W			2584	-	-
148 FSO	(S)	N	0	45.995	W	85	53.957	2533	+	774
	(E)	N	0	46.146	W	85	54.854	2587	+	
149 FSO	(S)	N	0	46.049	W	85	54.733	2580	+	432
	(E)	N	0	45.986	W	85	54.624	2534	+	
150 GTVC		N	0	46.00	W	85	54.8	2389	-	20
151 GK		N	0	38.058	W	88	26.877	2450	-	41
152 FSO	(S)	N	2	02.076	W	91	37.028	1875	+	401
	(E)	N	2	02.532	W	91	36.168	1870	+	
153 FSO	(S)	N	2	06.251	W	91	57.493	1594	+	716
	(E)	N	2	06.452	W	91	57.211	1898	[illegible]	
154 FSO	(S)	N	2	29.540	W	93	41.791	2400	+	768
	(E)	N	2	29.430	W	93	40.670	2292	+	
155 FSO	(S)	N	2	29.739	W	93	43.363	2394	+	610
	(E)	N	2	28.871	W	93	42.841	2339	-	
156 FSO	(S)	N	2	37.584	W	94	58.732	2813	+	7[illegible]
	(E)	N	2	37.745	W	94	58.952	2704	-	
157 FSO	(S)	N	2	30.209	W	93	45.797	2322	-	749
	(E)	N	2	28.854	W	93	43.721	2233	-	
158 GK		N	1	51.101	W	90	59.308	2298	-	43
159 GK		N	1	06.442	W	90	38.113	2249	-	2
160 GK		N	0	52.871	W	90	39.079	2236	-	38
161 GK		N	0	55.920	W	89	43 712	2109	-	40
162 FSO	(S)	N	0	47.417	W	89	19.461	1699	-	710
	(E)	N	0	46.179	W	89	18.802	1815	-	
163 GK		N	0	41.532	W	89	04.542	2281	-	28
164 GK		N	0	48.330	W	88	26.500	2256	-	18

S T A T I O N - L I S T continued

GARIMAS 2 (all Stations)

STATION NO.		LATITUDE	DEG	MIN	LONGITUDE	DEG	MIN	DEPTH M	SUB-POSITION	RECOVERY
165 FSO	(S)	N	0	43.708	W	88	23.869	2025	-	320
	(E)	N	0	45.209	W	88	23.687	1984	-	
166 FSO	(S)	N	0	43.388	W	88	08.206	2032	-	194
	(E)	N	0	44.204	W	88	08.206	2101	-	
167 FSO	(S)	N	0	49.388	W	86	27.827	2416	-	328
	(E)	N	0	49.660	W	86	26.449	2403	-	
168 CTVC		N			W			2516	-	-
169 CTVB		N	0	46.0	W	85	54.7	2562	-	476
170 CTVB		N	0	46.037	W	85	54.955	2574	-	70
171 CTVB		N	0	45.963	W	85	54.603	2573	-	730
172 FSO	(S)	N	0	46.094	W	85	57.387	2557	+	374
	(E)	N	0	46.290	W	85	56.489	2572	+	
173 CTVB		N			W			2588	-	-
174 CTVB		N			W			2526	-	-
175 MS+H		N	0	46.016	W	85	54.646	2574	-	-
176 FSO	(S)	N	0	44.817	W	85	49.903	2531	+	737
	(E)	N	0	45.246	W	85	49.709	2608	+	
177 CTVC		N	0	45.889	W	85	54.785	2531	-	200
178 CTVB		N			W			2539	-	-
179 FSO	(S)	N	0	46.251	W	85	58.277	2587	+	0
	(E)	N	0	47.119	W	85	57.449	2532	+	
180 CTVE		N			W			2567	-	-
181 CTVA		N	0	46.045	W	85	54.626	2529	-	300
182 FSO	(S)	N	0	46.231	W	85	55.074	2537	+	270
	(E)	N	0	46.267	W	85	54.023	2604	+	
183 FSO	(S)	N	0	45.268	W	85	51.124	2580	+	684
	(E)	N	0	45.387	W	85	49.212	2632	-	
184 CTVA		N			W			2512	-	-
185 CTVA		N	0	46.168	W	85	54.693	2528	-	500
186 FSO	(S)	N	0	46.283	W	85	53.970	2588	+	746
	(E)	N	0	46.229	W	85	54.420	2585	+	
187 FSO	(S)	N	0	45.978	W	85	55.360	2520	+	724
	(E)	N	0	45.033	W	85	53.636	2526	+	
188 CTVA		N	0	46.102	W	85	55.100	2535	-	350
189 CTVA		N	0	45.965	W	85	54.921	2584	-	150
190 FSO	(S)	N	0	46.109	W	85	56.799	2586	+	733
	(E)	N	0	46.469	W	85	56.139	2523	+	
191 FSO	(S)	N	0	44.934	W	85	49.139	2508	+	724
	(E)	N	0	45.181	W	85	49.782	2616	-	
192 D		N	0	54.885	W	85	53.156	2590	-	5
193 FSO	(S)	N	0	45.807	W	85	54.526	2531	+	690
	(E)	N	0	45.969	W	85	53.169	2602	+	
194 FSO	(S)	N	0	45.445	W	85	52.804	2500	+	503
	(E)	N	0	44.823	W	85	51.184	2620	-	
195 D		N	0	46.116	W	85	55.202	2574	-	30
196 CTVA		N	0	46.235	W	85	33.260	2605	-	15
197 FSO	(S)	N	0	48.967	W	86	25.858	2445	+	567
	(E)	N	0	49.540	W	86	23.058	2573	+	
198 FSO	(S)	N	0	49.509	W	86	25.068	2496	+	675
	(E)	N	0	49.138	W	86	23.331	2470	-	

S T A T I O N - L I S T continued

CARIMAS 2 (all Stations)

STATION NO.	LATITUDE DEG	LATITUDE MIN	LONGITUDE DEG	LONGITUDE MIN	DEPTH M	SUB-POSITION	RECOVERY
199 FSO (S)	N 0	47.865	W 85	44.711	2551	+	169
(E)	N 0	47.376	W 85	43.972	2768	+	
200 GTVC	N		W		2609	-	-
201 GTVA	N		W		2570	-	-
202 GTVA	N 0	46.056	W 85	54.781	2568	-	353
203 FSO (S)	N 0	45.096	W 85	50.644	2508	+	0
(E)	N 0	45.079	W 85	50.693	2610	+	
204 GTVA	N 0	44.950	W 85	50.641	2611	-	50
205 GTVA	N		W		2613	-	-
206 FSO (S)	N 0	46.203	W 85	54.978	2585	+	431
(E)	N 0	45.828	W 85	54.206	2538	+	
207 GTVA	N 0	46.039	W 85	54.594	2515	+	269
208 FSO (S)	N 0	45.789	W 85	52.807	2614	+	752
(E)	N 0	45.748	W 85	51.493	2514	+	
209 GTVC	N 0	45.627	W 85	52.046	2537	-	1
210 GTVC	N 0	45.689	W 85	54.622	2523	-	400
211 FSO (S)	N 0	46.512	W 85	54.352	2539	+	277
(E)	N 0	45.978	W 85	54.113	2502	+	
212 FSO (S)	N 0	46.281	W 85	53.626	2516	+	474
(E)	N 0	46.202	W 85	52.830	2509	-	
213 GTVC	N 0	45.978	W 85	54.602	2514	-	960
214 FSO (S)	N 0	45.415	W 85	39.932	2413	-	737
(E)	N 0	44.111	W 85	40.167	2597	-	
215 GTVC	N 0	46.123	W 85	54.742	2533	-	397
216 GTVC	N		W		2598	-	-
217 FSO (S)	N 0	45.695	W 85	51.904	2612	+	732
(E)	N 0	45.627	W 85	51.898	2518	+	
218 D	N 0	45.7	W 85	52.0	2623	-	300
219 GTVC	N		W		2513	-	-
220 GTVA	N		W		2604	-	-
221 GTVC	N 0	44.957	W 85	50.734	2620	-	400
222 FSO (S)	N 0	45.108	W 85	50.794	2603	+	421
(E)	N 0	45.116	W 85	50.475	2557	+	
223 GTVC	N		W		2558	-	-
224 GTVA	N 0	45.895	W 85	54.594	2557	-	3
225 FSO (S)	N 0	46.852	W 85	58.528	2566	+	749
(E)	N 0	46.305	W 85	57.454	2579	-	
226 GTVC	N 0	45.001	W 85	50.707	2603	-	50
227 FSO (S)	N 0	46.295	W 85	56.167	2559	+	50
(E)	N 0	46.216	W 85	55.975	2521	+	
228 GTVC	N 0	46.724	W 85	58.435	2525	-	1480

MS+H = MULTISONDE + WATER SAMPLING
GTVA,GTVB,GTVC = TV-GRAB (kg)
GK = BOXGRAB (cm)
K = BOXCORER (cm)
FSO = PHOTOSLEDGE (Number of Photos)
CS = CURRENT MEASUREMENT

15. PHOTO TABLES

P H O T O   T A B L E   1

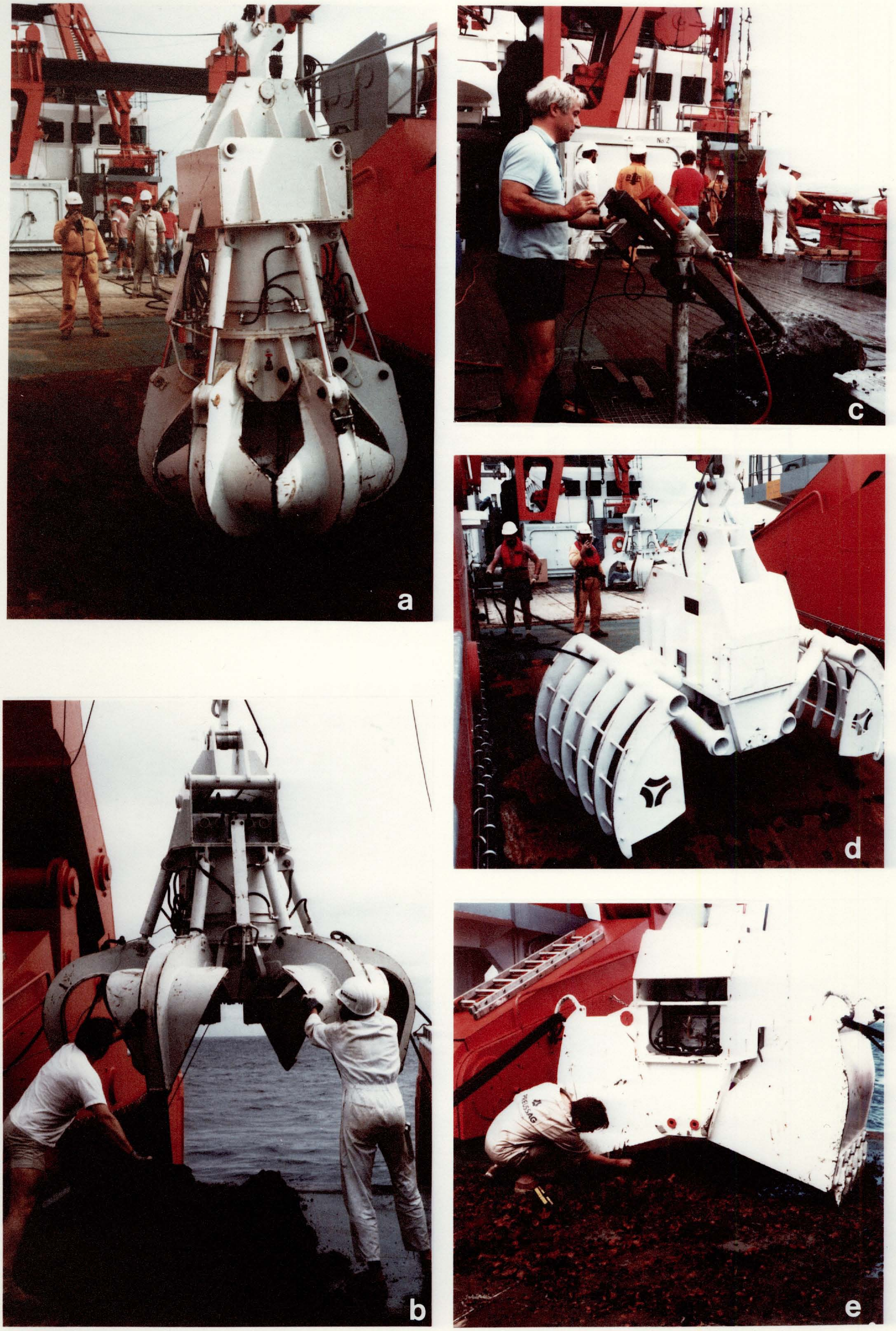
A. ELECTRO-HYDRAULIC TV-GRAB ("GRAPPLER" OR GTVC) DURING RETRIEVING

B. THE "GRAPPLER" AFTER RELEASE OF SULPHIDES

C. DRILLING OF SULPHIDE CORES FOR GEOTECHNICAL TESTS

D. LAUNCHING OF THE ELECTRO-HYDRAULIC TV-GRAB (FORK-GRAB OR GTVB)

E. THE ELECTRO-HYDRAULIC TV-GRAB GTVA OR "CLAMSHELL" AFTER OPERATION.


a
c
d
b
e

P H O T O   T A B L E   2

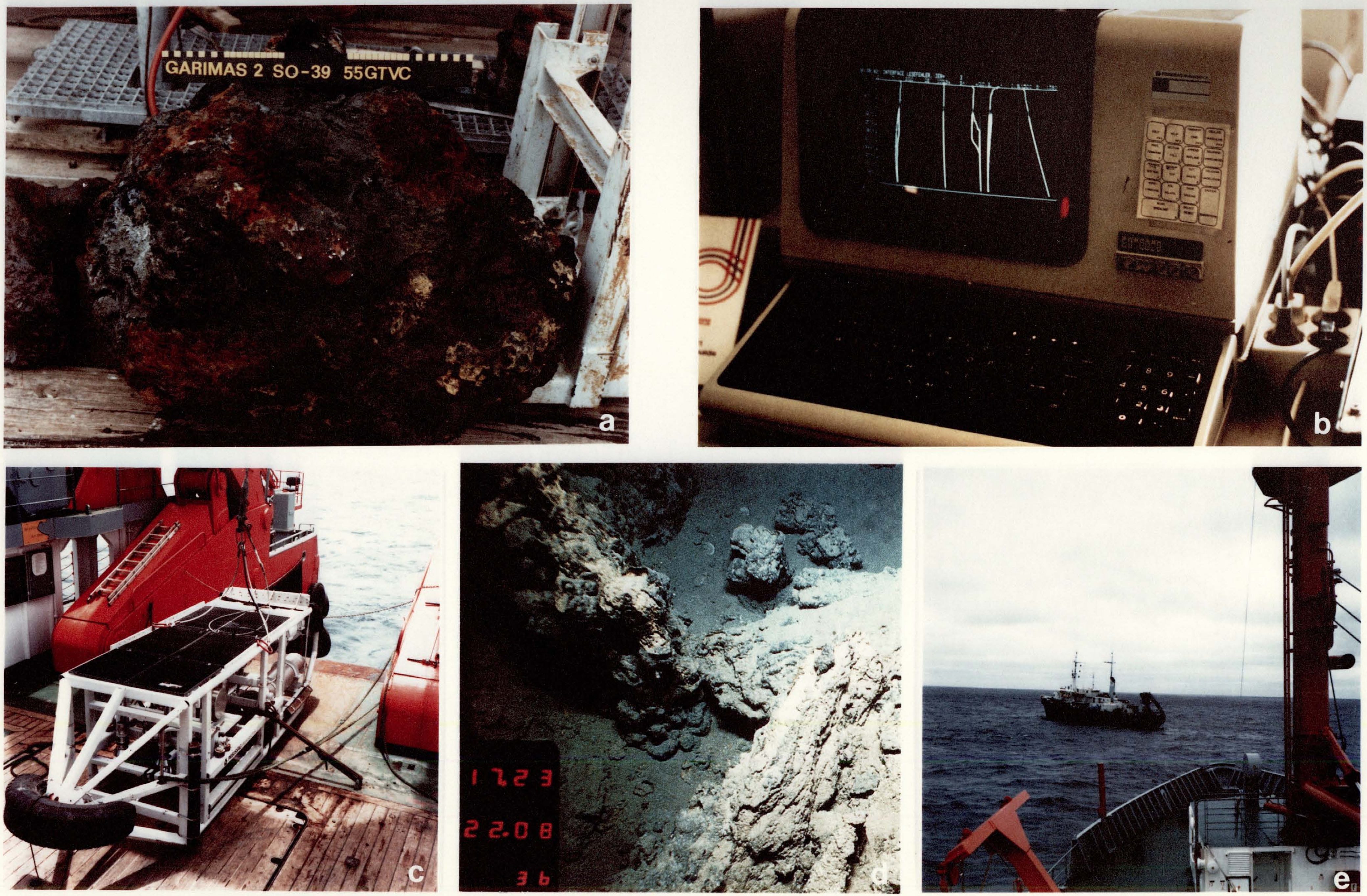
A. SULPHIDE BOULDER SAMPLED WITH THE GTVC

B. VIDEO TERMINAL "VT 100" OF THE PDP/LSI 11/23 COMPUTER SYSTEM WITH A MULTISONDE ON-LINE PLOT

C. OFOS (OCEAN FLOOR OBSERVATION SYSTEM)

D. DEEP OCEAN BOTTOM PHOTO TAKEN WITH THE PHOTO-DEVICE OF THE OFOS

E. THE AMERICAN RESEARCH VESSEL "ATLANTIS II" IN FRONT OF R.V. "SONNE"


GARIMAS 2 SO-39 55GTVC
a
b
17.23
22.08
36
c
d
e

P H O T O   T A B L E   3

OFOS-PHOTO OF A MASSIVE SULPHIDE BOULDER,
A TYPICAL FRAGMENT OF A HYDROTHERMAL STACK.

OFOS Ocean Floor Observation System